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## USSR: Physics & Mathematics

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UDC 534

**Thermal Self-Focusing of Weak Shock Waves**  
*18620107a Moscow AKUSTICHESKIY ZHURNAL*  
*in Russian Vol 35 No 1, Jan-Feb 89 (manuscript*  
*received 10 Jan 88) pp 67-70*

[Article by A. A. Karabutov, O. V. Rudenko and O. A. Sapozhnikov, Physics Faculty, Moscow State University imeni M. V. Lomonosov]

[Abstract] Self-focusing is one of the manifestations of the self-action of acoustic waves. A study was made of thermal self-focusing (TSF) of weak shock waves against a background of quadratic effects. The latter do not so much mask the TSF as intensify it. With a nonlinear nature of sound absorption the transfer of wave energy to the medium transpires more intensively than in the case of linear absorption. This is manifested particularly strongly during the formation of weak shock waves when dissipation on forming discontinuities occurs. The article describes experiments in which the TSF of ultrasound is registered under conditions of (and due to) formation of weak shock waves. Acetone was selected as the medium for studying TSF since it has a quite high speed-of-sound temperature coefficient and acoustic nonlinearity parameter. The experimental scheme is described in detail; measurements were made at 2 MHz. The self-focusing effect is manifested in a change in the transverse distribution of wave intensity during its propagation. It is demonstrated that the effect is attributable to the thermal self-action of ultrasound. In fixed media the TSF effect may exert a great influence on propagation of a powerful acoustic beam. Figures 4; references: 3 Russian.

UDC 534.6.08

**Temperature Effects in Focal Region of Acoustic Microscope**

*18620107b Moscow AKUSTICHESKIY ZHURNAL*  
*in Russian Vol 35 No 1, Jan-Feb 89 (manuscript*  
*received 20 Apr 88) pp 84-90*

[Article by R. G. Mayev and K. I. Maslov, Chemical Physics Institute, USSR Academy of Sciences]

[Abstract] When studying materials using a scanning acoustic microscope in some cases it is necessary to make allowance for the effects of heating of the investigated sample. Such heating is caused by both absorption of ultrasound directly in an object positioned in the focal region of the microscope and by heat transfer to the sample from the immersion fluid, which absorbs ultrasound, in which the sample is placed. The article gives approximate computations of the maximal temperature increase in a homogeneous sample occupying a half-space under the condition that the radiating lens moves uniformly along the surface of the investigated sample. Computations were made for the two most characteristic cases corresponding to the two main uses of acoustic

microscopy. The first case corresponds to investigation of objects whose thermophysical properties differ little from the properties of water, the traditional immersion fluid (biological objects, in particular, belong to this class). In this case it is assumed that the sample and the immersion fluid constitute a medium with homogeneous thermal properties with different ultrasound absorption coefficients. In such a system the distribution of temperature sources is determined by the ultrasound absorption coefficient and distribution of sonic pressure in the focal region of the acoustic microscope. The second case corresponds to investigation of objects in which ultrasound absorption is negligible in comparison with absorption in the immersion medium and the heating of the sample is determined for the most part by heat diffusion from the immersion medium adjacent to the sample. Research on solid-state samples, such as metals, semiconductors and ceramics, belongs to this class. The thermal conductivity for such materials is usually 2-3 orders of magnitude greater than the thermal conductivity of the immersion fluid. Examination of these cases shows that with different relations of the properties of the sample and immersion medium the upper estimate for temperature in the focal region, with allowance for rapidly variable and stationary heating, does not exceed a degree in the case of "biological" samples and  $10^{-2}$  in the case of "solid state" samples. This makes it possible, with assurance, to interpret the measurements of properties of materials obtained in acoustic microscopy associated directly or indirectly with temperature variations. Figure 1; references 14: 10 Russian, 4 Western.

UDC 535.41

**Analysis of Holographic Interferograms of Ultrasonic Quartz Crystal Transducers in Research on Spatial Oscillations**

*18620084a Moscow AKUSTICHESKIY ZHURNAL*  
*in Russian Vol 34 No 6, Nov-Dec 88 (manuscript*  
*received 22 Mar 86) pp 998-1003*

[Article by R. S. Vasilyauskas, A. P. Palyavichyus and K. M. Ragulskis, Kaunas Polytechnic Institute imeni Antanas Sneckus]

[Abstract] In research on oscillations of ultrasonic quartz crystal transducers it is necessary to determine the amplitude-frequency characteristics of the radiating surface, which in most cases experiences spatial oscillations. A method is proposed for computing the characteristics of these spatial oscillations which makes it possible to solve timely problems in investigation, designing, checking and diagnosis of ultrasonic transducers. The method makes it possible to compute the amplitudes of the normal and tangential components of the vector of spatial oscillations of the surface of deformable crystal quartz transducers on the basis of experimental data from holographic interferometry and the theory of oscillations of mechanical systems. In contrast to earlier proposals, this method, based on computations using holographic interferograms, makes it possible to employ

a considerably lesser quantity of initial data. Specific formulas are derived which make it possible to compute the amplitudes of the normal and tangential components of the vector of spatial oscillations of any surface point. The method is also applicable in analyzing holographic interferograms of spatial oscillations of solid deformable bodies of any geometry. Figures 3; references 8: 6 Russian, 2 Western.

UDC 534.16

**Propagation of Rayleigh Wave Through Smooth Large-Scale Surface Irregularities**

18620084b *AKUSTICHESKIY ZHURNAL in Russian*  
Vol 34 No 6, Nov-Dec 88 (manuscript received  
18 Feb 88) pp 1071-1080

[Article by V. V. Krylov, Physics Faculty, Moscow State University imeni M. V. Lomonosov]

[Abstract] As demonstrated in an earlier article by the author (AKUST. ZHURN., Vol 25 No 5, 1979), in the general case of a three-dimensional surface geometry the influence of irregularities is manifested primarily in the appearance of velocity anisotropy of Rayleigh waves transmitted through them and their refraction relative to geodesics in a case when the surface curvature changes along the propagation trajectory. This refraction is the reason for wave guide propagation of surface waves in smooth topographic wave guides. The dispersion equations for wave guides of different configurations were given by the author in AKUST. ZHURN, Vol 33 No 4, 1987. Continuing this work, the author has now determined the ray trajectories of surface waves passing through smooth large-scale irregularities since this may be critical in solving many practical problems in ultrasonic defectoscopy and seismology, such as in computations of fields behind an obstacle or when determining the position of the source of sound or a defect and also in acoustoelectronics when computing delay lines with rounded-off surfaces and high-quality geodesics. Equations are derived for surface rays and computational data are given for a number of typical irregularities in the form of axisymmetric depressions or bulges. The case of propagation of a Rayleigh wave through homogeneous-inhomogeneous obstacles, cylinders of variable curvature, is also examined; all the reasonings presented for axisymmetric inhomogeneities are fully applicable to this case. Figures 6; references 17: 15 Russian, 2 Western.

UDC 534.2:532

**Theory of Sound Generation and Propagation in Nonstationary Flow**

18620084c *Moscow AKUSTICHESKIY ZHURNAL in Russian*  
Vol 34 No 6, Nov-Dec 88 (manuscript received 25 Feb 88) pp 1109-1115

[Article by A. T. Fedorchenko, Moscow Physical Technical Institute]

[Abstract] Until now it has been impossible to derive a single system of equations for simultaneously describing the processes of generation and propagation of acoustic

disturbances in subsonic flows with a rapidly changing spatial structure. A theoretical model of generation and propagation of sound in a nonstationary flow with an inhomogeneous entropic field is proposed which differs fundamentally from earlier known approaches. A method for discriminating the acoustic components of velocity, pressure and density is described. Nonlinear (precise) and linearized systems of differential equations are derived for describing the investigated phenomena. A variant of a model in which solutions are found within the framework of the incompressible fluid approximation is also examined. The described theoretical model was used successfully in an analysis of a number of complex acoustic phenomena in eddy flows which were simultaneously investigated using methods for the numerical integration of the nonlinear equations of gas dynamics. References 12: 6 Russian, 6 Western,

**Acoustoelectronic Interaction of Surface Waves in GaAs-InGaAs Superlattices**

18620081b *Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian*  
Vol 14 No 20, 26 Oct 88 (manuscript received  
12 Jun 88) pp 1911-1914

[Article by V. A. Vyun, Yu. O. Kanter, S. M. Kikkarin, V. V. Pnev, A. A. Fedorov and I. B. Yakovkin]

[Abstract] Although there has been considerable interest in semiconductor superlattices, the interaction of acoustic waves with the charge carriers in them has been given no attention. This article gives the first experimental data on the acoustoelectronic interaction of the superlattice of GaAs-InGaAs during the propagation of surface acoustic waves. The properties of the superlattice are manifested most clearly in the transverse acoustoelectric effect. In an experiment surface acoustic waves were generated in a GaAs backing at a frequency 140 MHz by a high-frequency voltage transducer. All research was at room temperature. Data were obtained on the dependence of the amplitude of the acoustoelectric effect on different current strengths for different intensities of surface acoustic waves. It was found that the redistribution of free charge carriers within the limits of each layer and between layers (40 layers were formed) under the influence of a flowing current and surface acoustic waves leads to a new mechanism of nonlinear acoustoelectronic interaction more intense than the known concentration mechanism. The experiments revealed the essential features of superlattices even at room temperature. Figures 2; references: 5 Russian.

UDC 548:[537.611.43:539.124]

**Magnetic Generation of Ultrasound by Thin Films of Concentrated Paramagnetics**

18620090b *Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian*  
Vol 31 No 9, Sep 88 (manuscript received 9 Dec 86)  
pp 106-108

[Article by F. L. Aukhadayev and R. Sh. Zhdanov, Kazan State University imeni V. I. Ulyanov-Lenin]

[Abstract] The generation of plane ultrasonic waves by a  $\text{LiDyF}_4$  film applied to one of the plane-parallel ends of a diamagnetic  $\text{LiYF}_4$  monocrystal was discovered. The

investigated sample was a cylinder with a diameter of 6.8 mm and a length of 4.5 mm with a generatrix coinciding with the crystallographic axis [001]. The  $\text{LiDyF}_4$  film was applied by the thermal deposition method. The sample with a sprayed  $\text{LiDyF}_4$  film was placed in an induction coil in such a way that a variable magnetic field with a pulse strength of about 30 oe was situated in the plane of the film and a constant magnetic field was perpendicular to the plane of the film. Measurements were made at helium temperatures. The measured velocity of the ultrasonic wave corresponded to the velocity of propagation of transverse sound in  $\text{LiYF}_4$  along the direction [001]. The generation of plane transverse oscillations in  $\text{LiYF}_4$  is attributable to the fact that the diameter of the film greatly exceeds its thickness. It is evident that films of paramagnetic compounds with high magnetostriction can be used as a magnetoacoustic transducer. The following are the advantages of a film paramagnetic magnetostriction transducer: high strength of the joining of the film to the sample; absence of acoustic binding; high efficiency of transformation at low temperatures; possibility of an influence on generation efficiency. Figures 2; references: 4 Russian.

UDC 551.463.228

#### **Anisotropy of Oceanic Noise Field Experiment and Calculation**

18620164a Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 34 No 2, Mar-Apr 88 (manuscript received 13 May 87) pp 215-221

[Article by A. A. Aredov, N. N. Okhrimenko, and A. V. Furduev, Institute of Acoustics imeni N.N. Andreyev, USSR Academy of Sciences]

[Abstract] Anisotropy of the noise field in a vertical plane through the abyssal zone of a deep open sea with a characteristic tropical sound velocity profile is evaluated by comparing the results of measurements and calculations. Measurements were made with a 19 m long vertical linear antenna array of 32 equidistant hydrophones having a sensitivity of 200 mV/Pa and a frequency range of 0.3-1.2 kHz, each having a preamplifier with a spectral level of electrical noise not higher than 10 nV/Hz<sup>0.5</sup>. Calculations were made on a computer on the basis of the geometrical acoustical model describing dynamic and navigational ocean noise, with scattering by the ocean bed taken into account by Lament's law. Figures 3; references 10: 6 Russian 4 Western.

UDC 534.88

#### **Apparatus for Shaping Radiation Pattern of Linear Acoustic Antennas**

18620164c Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 34 No 2, Mar-Apr 88 (manuscript received 26 Jun 87) pp 237-240

[Article by F. V. Bunkin, A. V. Vavilin, N. N. Valko, Yu. A. Kravtsov, Yu. A. Magarshak, V. G. Petnikov, A. V. Ravvin, A. S. Sokolenko, and L. P. Khokhrin, Institute of General Physics, USSR Academy of Sciences]

[Abstract] An apparatus for shaping the radiation pattern of linear acoustic antennas has been developed and built which consists essentially of a multichannel phase

distortion correction and an Elektronika-60 microcomputer. Its distinguishing feature is phase correction by heterodyning rather than by conventional formation of phase shifts by means of delay lines. While this phase corrector can operate only with narrow-band signals, just as all other phase shifting devices, the possibility of regulating the heterodyne frequency over the 50-1000 Hz range extends the width of the signal band from the conventional maximum 17 Hz up to 1000 Hz. The phase corrector has 48 channels and a direct-access memory consisting of four switchable cells, one for phasing in each of the four directions, a magnetic disk being available for permanent data storage. The software for automatic operation includes phase readout and averaging programs designed for maximum accuracy in the presence of acoustic noise as well as phase correction and heterodyne phasing programs. The apparatus with this software was tested on a quasi-linear horizontal hydroacoustic array consisting of 20 equidistant hydrophones with a 0.47 ratio of array period to sound wavelength. Figures 2; references 2: Russian.

UDC 681.883

#### **Effect of Vortex Within Thermal Wedge on Acoustic Field of Point Source in Ocean**

18620164d Moscow *AKUSTICHESKIY ZHURNAL* in Russian Vol 34 No 2, Mar-Apr 88 (manuscript received 15 May 87) pp 280-284

[Article by A. N. Nekrasov, Institute of Acoustics imeni N.N. Andreyev, USSR Academy of Sciences]

[Abstract] The effect of a mesoscale vortex on the acoustic field of a point source in an ocean is analyzed by numerical simulation. A horizontal rotating warm brine lens quasi-circular in the plan view and located 1 km deep, similar to the one observed in the tropical zone of the Atlantic Ocean during the Mesopolygon-85 expedition is examined as the vortex: approximately 400 m thick and of the order of 80 km wide, with the velocity of sound deviating from its quiescent level by 16 m/s at the center. The algorithm of calculations based on geometrical acoustics for a three-dimensionally nonhomogeneous medium, assuming that the ocean occupies the entire lower half-space in a Cartesian system of coordinates, includes scanning that half-space for sound rays propagating from the source to the receiver. Calculations made with the aid of an SM-4 minicomputer indicate that the effect of such a relatively narrow lens-vortex can become perceptible even when both source and receiver are located within a 300 m thick surface layer. The author thanks N.Ye. Maltsev and K.d. Sabinin for attentiveness and support. Figures 4; tables; references 8: 7 Russian, 1 Western (in Russian translation).



UDC 551.463

**Differential Acoustic Examination of Random Ocean Inhomogeneities**

18620164e Moscow AKUSTICHESKIY ZHURNAL  
in Russian Vol 34 No 2, Mar-Apr 88 (manuscript  
received 4 May 87) pp 285-289

[Article by A. G. Nechayev and A. I. Khilko, Institute of  
Applied Physics, USSR Academy of Sciences]

[Abstract] Combining the principle of tomography and the method of pulsed strobing, with directional signal transmission and reception, makes it possible to locate inhomogeneities in an acoustic medium with the aid of a single signal which has passed through a given region of that medium. The concept is applied to "through sounding" of an ocean for differential acoustic examination of its random inhomogeneities. After the transmitter has excited an oceanic waveguide mode  $n$  and before the receiver will extract another mode  $m$  with a different group velocity, an inhomogeneity along the path at some distance from the transmitter transfers energy from mode  $n$  to mode  $m$ . Selection of modes is facilitated not only by use of long vertical antennas and adjustment of their depth but also by existence of natural "mode shadow" zones in the ocean. The statistical characteristics of subsurface sound velocity perturbations as well as the surface relief of a rough ocean region can be then determined from the envelope of pulse signal intensity. As an example is considered an oceanic surface layer with a linear depthwise sound velocity profile, the emergence angle of a Brillouin wave depending on the group velocity of the waveguide mode  $n$ , and a horizontally radiating vertical transmitter antenna. The authors thank L.S. Dolin and V.I. Talanov for discussion and helpful comments. Figures 2; references 13: 12 Russian, 1 Western.

UDC 534.8:143

**Excitation of Hypersound at Boundary Between Type-II Superconductor and a Concentrated Paramagnetic Compound**

18620164f Moscow AKUSTICHESKIY ZHURNAL  
in Russian Vol 34 No 2, Mar-Apr 88 (manuscript  
received 6 Nov 86) pp 315-320

[Article by S.L. Tsarevskiy, Department of Physics,  
Kazan State University imeni V.I. Ulyanov-Lenin]

[Abstract] The boundary without acoustic contact between a type-II superconductor and a paramagnetic rare-earth compound is considered, assuming that the paramagnetic compound with a regular sublattice of paramagnetic ions occupies an entire half-space and the superconductor is a sufficiently thick plate of infinite length but finite width. When a transverse external magnetic field consisting of a constant component and an alternating one is applied, a strongly nonuniform magnetic field with the periodicity of a two-dimensional vortex structure appears in the superconductor near its interface with the paramagnetic. Analysis of strains in such a system, with its Hamiltonian represented as the sum of a quiescent component (energy of phonons and energy of ions in the crystal field) and a perturbation component (Zeeman energy of ions and energy of spin-phonon interactions), indicates that gigahertz Rayleigh surface acoustic waves are excited as a result. Numerical estimates of their amplitude of 10 GHz frequency are shown for a type-II superconductor on a concentrated  $\text{LiLnF}_4$  paramagnetic or a van Vleck  $\text{LiTiF}_4$  paramagnetic, in a constant magnetic field of 900 Oe and an alternating one of 1-5 Oe. With such materials it is shown to be feasible to generate hypersonic surface acoustic waves of up to 50 GHz frequency and up to 10  $\text{W/cm}^2$  intensity, absence of an acoustic contact between the two media being essential at these high frequencies. The author thanks B.I. Kochelayev and participants of the seminar under his chairmanship for attentiveness and discussion. References 15: 11 Russian, 4 Western (1 in Russian translation).



UDC 535.338:621.378

**Increasing Sensitivity of Intracavity Laser Spectrometers by Means of Negative Feedback**  
18620022d Minsk *ZHURNAL PRIKLADNOY SPEKTROSKOPII* in Russian Vol 49 No 1, Jul 88  
(manuscript received 18 Feb 87) pp 130-134

[Article by S. F. Lukyanenko and M. M. Makogon]

[Abstract] Both wideband and narrow-band variants of intracavity laser spectroscopy are considered, the laser emission line being respectively much wider and much narrower than the absorption line of the analyzed substance and the spectral resolution in the narrow-band variant being much higher but the sensitivity lower than in the wideband variant. The feasibility of increasing the sensitivity in both variants by means of negative feedback, ensuring spectral stability over the entire pulse duration in the wideband variant and higher emission stability near the emission threshold in the narrow-band variant, is demonstrated theoretically on the basis of a single-mode traveling-wave ruby or neodymium laser as applicable mode. Analysis and calculations are based on its two equations of kinetics, for the mean radiation intensity and the relative population inversion respectively, as well as on the expression for the threshold sensitivity. Numerical results indicate that the sensitivity of wideband intracavity laser spectroscopy can be thus increased by a factor of 10-100, while the sensitivity in the narrow-band variant can be thus increased by a factor of 100-1000 without degradation by quantum noise. Figures 2; references 3: 1 Russian, 1 Western.

UDC 535.37

**Gadolinium-Scandium-Aluminum and Yttrium-Scandium-Aluminum Garnet Crystals as Active Media for Solid-State Lasers in 1.5 m Range**

18620099a Minsk *ZHURNAL PRIKLADNOY SPEKTROSKOPII* in Russian Vol 49 No 3, Sep 88  
(manuscript received 13 Jul 87) pp 430-435

[Article by A. L. Denisov, Ye. V. Zharikov, A. I. Zagumenny, S. P. Kalitin, V. A. Smirnov, A. I. Talybov and I. A. Shcherbakov]

[Abstract] Crystals of gadolinium-scandium-aluminum (GSAG) and yttrium-scandium-aluminum (YSAG) garnets, doped with  $\text{Gr}^{3+}$ ,  $\text{Yb}^{3+}$  and  $\text{Er}^{3+}$ , were synthesized. Figures 1 and 2 illustrate the absorption and luminescence spectra of the synthesized crystals. A quantitative study of spectral-luminescent energy transfer processes in GSAG—Gr, Yb, Er and YSAG—Gr, Yb, Er crystals was made using known nonstationary methods assuming "instantaneous" excitation of the sample and analysis of decay curves of excited states of interacting particles. It is concluded on the basis of investigation of the spectral luminescent properties and processes of collective interactions in these crystals that they can be recommended

as materials for creating active media for erbium lasers operating at room temperature in the 1.5  $\mu\text{m}$  range. Figures 3; references 21: 18 Russian, 3 Western.

UDC 538.9

**Structure of Wigner Crystal**

18620013b Tomsk *IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKIA* in Russia Vol 31 No 6, Jun 88 (manuscript received 3 Nov 86) pp 47-51

[Article by R. Kh. Sabirov, Moscow Pedagogical Institute imeni V. I. Lenin]

[Abstract] An electron gas condensing into a Wigner crystal with low electron concentration having been described by W. J. Carr as an array of identical cells with one electron per cell and with the energy per electron a power-series function of the interelectronic distance, according to M. Gell-Mann and K. A. Brueckner but the series being in negative powers only, the effect of decreasing that distance is analyzed on the basis of the corresponding Schroedinger equation. The possibility of an ordered state with two electrons per cell within a definite range of electron concentration having already been established, it is now demonstrated that crystals with two or successively more electrons per cell can exist as the interelectronic distance decreases. Accordingly, a crystal with an interelectronic distance much smaller than the Bohr radius is equivalent to one cell with high electron concentration. References 7: 3 Russian, 4 Western (3 in Russian translation.).

UDC 621.315.592

**New Mechanism of Nonradiative Capture of Holes in GaAs to Deep Level of Structural Defect**

18620003a Kiev *DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI* in Russian No 6, Jun 88  
(manuscript received 29 Oct 87) pp 54-57

[Article by M. V. Strikha, Institute of Semiconductors, UkSSR Academy of Sciences, Kiev]

[Abstract] A new mechanism of nonradiative capture of holes in GaAs to the deep level of an EL2 donor center is proposed which explains the nature of this recombination process consistently with experimental EPR data on the temperature dependence of thermally stimulated hole tunneling, which the multiphonon mechanism does not. The physical model is based on the premise that EL2 levels appear upon replacement of a Ga atom by an As atom in the crystal lattice and that Auger capture of a hole to the deep EL2 level proceeds with attendant energy transfer to the electron by way of Coulomb interaction at the shallow EL2 level. The cross-section for capture of holes, calculated in the Born approximation for a Boltzmann distribution of free holes, confirms

that the mechanism is one in the class of Auger-transitions. Article was presented by Academician, UkSSR Academy of Sciences, O. V. Snitko. Figures 2; references 8: 6 Russian, 2 Western (1 in Russian translation).

**Activational Nature of Optically Induced Luminescence Recovery by EL2 Centers in GaAs**

18620002a Leningrad PISMA V ZHURNAL  
TEKHNICHESKOY FIZIKI in Russian  
Vol 14 No 12, 26 Jun 88 (manuscript received 1 Feb 88)  
pp 1067-1071

[Article by Ye. I. Oborina, S. S. Ostapenko, and M. K. Sheynkman, Institute of Semiconductors, UkSSR Academy of Sciences]

[Abstract] An experimental study of EL2 centers in GaAs was made concerning the temperature dependence of the kinetics of their photoluminescence fatigue and light-induced photoluminescence recovery. Specimens of GaAs crystals known to optically recover the photoluminescence at temperatures above 60 K were specially selected for the experiment, their photoluminescence being monitored over a period of 180 s at temperatures of 4.2-80 K. Their photoluminescence fatigue was found to increase exponentially with a time constant almost independent on the temperature but depending on both wavelength and intensity of the excited glow. Determinations of optical recovery at 4.2 K were made on the basis of glow intensity measured at the onset of fatigue and on the basis of the light sum calculated by graphical integration of the area under the fatigue curve. Both initial fatigue and light sum were found to be proportional to the number of EL2 centers in the ground state, optical recovery of photoluminescence being thermally activated and on an isochronous basis following the Arrhenius equation. Figures 2; references 7: 1 Russian, 1 Hungarian, 5 Western.

**Effect on Relaxation on Nonlinear Waves in Crystals**

18620005a Moscow TEORETICHESKAYA I  
MATEMATICHESKAYA FIZIKA in Russian  
Vol 75 No 3, Jun 88 (manuscript received 22 Jun 87)  
pp 371-377

[Article by G. T. Adamashvili, Tbilisi State University]

[Abstract] The effect of transverse relaxation on a soliton of self-induced transparency in anisotropic crystals with nonuniform broadening of the spectral line is analyzed by the methods of inverse scattering-problem and perturbation theory, on which the theory of solitons is based. This mathematical apparatus is applied to propagation of a pulse of a plane extraordinary wave through a uniaxial crystal with low concentration of two-level impurity atoms, their transitions having dipole moments oriented parallel to the optical axis. Interaction of pulse and medium is assumed to be coherent, a necessary condition for self-induced relaxation. Assuming further

a "slow" variation of electric field and impurity polarization parameters, interaction of impurity atoms being ignored, standard procedure yields the Bloch-Maxwell equation for self-induced transparency for an extraordinary wave. Solution of this equation with the aid of the solution to an auxiliary problem, namely Zakharov-Shabat equations, yields a continuous spectrum of scattering data in the latter as a result of transverse relaxation. Its effect is further evident in the modified asymptotic expressions for the complex amplitude and the energy of an extraordinary-wave pulse and for the "reflection coefficient" of the medium. For a ruby crystal, specifically, integrals in these expressions have been evaluated by numerical methods. The author thanks S. V. Manakov for helpful discussions and Sh.S. Nikolaishvili for computer calculations. References 15: 10 Russian, 5 Western (1 in Russian translation).

UDC 548.4

**Influence of F-Centers in NaCl-Type Crystals on Diffuse X-Ray Scattering**

18620096a Leningrad FIZIKA TVERDOGO TELA  
in Russian Vol 30 No 10, Oct 88 (manuscript received  
23 May 88) pp 3164-3166

[Article by I. S. Braude, A. V. Gektin, P. M. Gluzman and V. Ya. Serebryanny, Monokristallreaktiv Scientific Production Association, Kharkov]

[Abstract] The presence of point defects (PD) in crystals results in crystal lattice deformation. The most effective method for investigating distortions induced by PD is diffuse X-ray scattering (DXRS). This method makes it possible to separate the contributions of PD elastic distortions of the vacancy and interstitial types. This article describes research on the contribution of PD to distortions of the crystal lattice in NaCl and KCl crystals by the DXRS method. Various very simple defects are examined, including F- and H-centers. The equilibrium configurations of ions surrounding the defects were computed. Only an F-center has an "effective volume" and this should be manifested on the "vacancy" branch of the dependence of the intensity of DXRS on scattering angle. The state of F- and X-centers was monitored spectrophotometrically. An analysis of the intensity of DXRS for additively colored crystals was made. The formation of metallic colloidal particles does not occur in the case of X-centers. However, additive coloring of NaCl results in the formation of colloidal particles surrounded by a metastable phase. In this case DXRS reveals the presence of defects of the vacancy type. Prolonged annealing (600°C, 4 hours) of additively colored NaCl results in the gradual dissolving of the metastable phase first and then the colloid due to losses of F-centers to the free surface. As a result of hardening to room temperature only vacancies remain in the crystal. DXRS for such samples in actuality reveals a distortion of the "interstitial" branch, consistent with computed data for vacancies. References 8: 6 Russian, 2 Western.

UDC 621.373.8

**Increasing Efficiency of Lasers With Neodymium in Active Medium**

18620022a Minsk ZHURNAL PRIKLADNOY  
SPEKTROSKOPII in Russian Vol 49 No 1, Jul 88  
(manuscript received 30 Apr 87) pp 15-19

[Article by A. D. Gondra, V. M. Gradov, V. V. Dybko, B. A. Konstantinov, G. I. Kromskiy, Yu. I. Rogalskiy, S. A. Smotryayev, Yu. I. Terentyev, and A. A. Shcherbakov]

[Abstract] The performance of new "light boiler" pumping schemes for Nd-glass and YAG:Nd lasers is analyzed, these schemes being designed to raise the efficiency of energy storage at the upper  $^4F_{3/2}$  level (relative to capacitive storage of electrical energy) during operation in the monopulse mode with Q-switching. They are based on utilization of superluminescence effects, which requires shortening the photon lifetime in the cavity at the laser transition frequency and thus decreasing the volume of the active medium and that of the discharge plasma while the optimum ratio of the two volumes is maintained. Experiments with several cylindrical Nd rods instead of one solid Nd tube between appropriate mirrors and with Q-switching by means of a shutter which disturbs total internal reflection have yielded gains and efficiencies approaching the theoretically attainable, but only at high energy levels. The authors thank A. B. Antropov, V. N. Makarov, and A. G. Saprykin for designing and supplying the shutter. Figures 3; references 10: Russian.

UDC 621.375.8

**Dye-Activated Epoxypolymer Laser Emitting Pulses of Microsecond Duration**

18620022a Minsk ZHURNAL PRIKLADNOY  
SPEKTROSKOPII in Russian Vol 49 No 1, Jul 88  
(manuscript received 25 May 87) pp 127-130

[Article by M. M. Asimov, T. B. Bermas, A. G. Varpakhovich, Yu. S. Zaytsev, Yu. V. Kostenich, M. K. Pakter, Yu. M. Paramonov, A. N. Rubinov, and T. Sh. Efendiyev]

[Abstract] A tunable visible solid-state laser was built by activating an epoxy-oligomer compound, heat-resistant and transparent for all visible radiation, with 0.1 wt.pct rhodamine 6G or 0.021 wt.pct rhodamine S at 60-90 deg C and subsequently curing the solution at 100-140 deg C. Transverse excitation was supplied by a coumarin-334/ethanol dye laser, a coaxial flashlamp, in pulses of 0.001. ms duration with a power density reaching 670 kW/cm<sup>2</sup> through a cylindrical focusing lens. Two plane mirrors with respectively 99 pct and 50 pct reflectance for 550-650 nm wavelengths formed the cavity. The luminescence spectra were measured with a spectrograph having a 0.6 nm/mm resolution. The energy characteristics were measured with an IMO-2N calorimeter. The

pulse duration was measured with coaxial FK-30 photocells and on an S8-13 oscillograph. Radiation emission in pulses of 200 mJ energy and 0.001 ms width at half-amplitude level was attained with both dyes, the luminescence quantum yield being 1.5 times higher with rhodamine 6G than with rhodamine S. Figures 1; tables 1; references 6: 3 Russian, 3 Western.

533.592

**Cylindrical Shock Waves Triggered in Helium by Radiation of CO<sub>2</sub>-Laser and Their Study by Methods of Holographic Interferometry**

18620181 Leningrad ZHURNAL TEKHNICHESKOY  
FIZIKI in Russian Vol 58 No 5, May 88 (manuscript  
received 9 Jun 86, in final version 4 Nov 87) pp 915-921

[Article by G.R. Toker, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] In an experimental model, a study of cylindrical shock waves, such as a shock wave that was triggered in helium by means of a radiation pulse of 4 J energy and 30 ns duration from a CO<sub>2</sub>-laser, this pulse impinging on a 3 mm thick aluminum target with a peak power density of 37 MW/cm<sup>2</sup> after it had been sharply focused by a cylindrical lens on 0.8 mm wide and 90 mm long surface segment of that target and the initial gas pressure being varied from atmospheric 760 mm Hg down to 190 mm Hg. The characteristics of such a shock wave were measured with a holographic interferometer, an OGM-20 ruby laser (684.3 nm) emitting pulses of 0.1 J energy and 30 ns duration being used as light source and active Q-switching of its cavity being synchronized with pulses of the CO<sub>2</sub>-laser. A slightly divergent probing beam was formed by a negative lens, the aperture of the object beam in the median plane of the target determining the dimensions of the field available for viewing the cylindrical wave and the thickness of the target determining the scale of the wave image. The interferometer was tuned to wavelength bands to finite widths by rotating an optical wedge during the interval between exposures. As the holographic medium served PL-3M-694 plates made available by the State Scientific Research Institute of Chemicals for Photography. The instrumentation also included a semiopaque mirror, a beam-splitting cube, a red light filter, a neutral filter, and a He-Ne laser (632.8 nm) for alignment. Processing of interferograms and shadowgrams together with theoretical calculations yielded information about the dynamics of shock wavefront buildup and propagation, including dependence of its velocity (Mach number) on its dimensionless radius (geometrical radius divided by "dynamic length"  $(E_0/p_1)^{1/2}$ ,  $E_0$ - linear density of incident energy,  $p_1$ - initial gas pressure) as well gas compression and electron concentration based on the shift of interference fringes. The author thanks S.I. Derzhavin and A.A. Sirotkin for personally participating in preparation and performance of the experiments. Figures 3; references 13: 12 Russian, 1 Western (in Russian translation).

UDC 621.373.826:537.525.5

### Argon Power Laser in Longitudinal Magnetic Field

18620185a KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 5, May 88 (manuscript received  
23 Mar 87) pp 922-932

[Article by A. A. Apolonskiy, S. A. Babin, V. I. Donin, and A. V. Nikonov, Institute of Automatic Control and Electrical Measurements, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] An experimental study of an Ar<sup>plus</sup>-laser in a longitudinal magnetic field was made, for the purpose of determining the laser performance and high-current plasma characteristics. The experiment was performed with a segmental discharge tube having a diameter of 16 mm and an active length of 55 cm. Measurements were made with a monochromator extracting each of the three Ar-I, Ar-II, Ar-III lines one at a time. These measurements have yielded the dependence of the radial electron-concentration and small-signal gain profiles, of the emission power and efficiency, of the longitudinal electric field component, of the population at both lower and upper lasing levels, and of the spontaneous-emission intensity on both the discharge current and the magnetic field intensity up to an optimum level of the latter, evidently owing to a beneficial effect of a longitudinal magnetic field on the longitudinal nonuniformity of the charge distribution, further increase of both emission power and efficiency with further increase of the magnetic field intensity being limited by preferential populating of the lower lasing level. The authors thank D. V. Yakovin for assisting in performance of the experiment. Figures 6; references 28: 15 Russian, 13 Western.

UDC 621.373.826.038.825.2

### Ho<sup>3+</sup>-Laser in Y-Sc-Ga Garnet Crystal with Q-Switching

18620185b KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 5, May 88 (manuscript received  
16 Sep 87) pp 960-961

[Article by A. N. Alpatyev, Ye. V. Zharikov, S. P. Kalitin, V. A. Smirnov, A. F. Umyskov, and I. A. Shcherbakov, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] An experimental study of Q-switching a Y-Sc-Ga:(Cr,Tu,Ho) garnet laser was made, such a laser emitting 2088 nm radiation at room temperature in pulses of up to 7 J energy with an absolute efficiency of 2.1 pct and a differential efficiency of 3.1 pct in the free-emission mode. The concentration of Cr,Tu,Ho ions in the 69 mm long crystal was held constant at  $2.5 \cdot 10^{20} \text{cm}^{-3}$ ,  $8 \cdot 10^{20} \text{cm}^{-3}$ ,  $5 \cdot 10^{19} \text{cm}^{-3}$  respectively. The cavity was formed by two plane quartz mirrors 40 cm apart, their reflection coefficient being 1.0 and 0.32 respectively. Switching was done by means of a prism rotating at a speed of 7500

rpm, either of them placed between the active medium and the high-reflectance mirror, while the active medium was pumped by an INP5/90 or INP5/6 flash lamp respectively. Both pump and switch were located inside a common elliptical silver-coated luminaire made of yellow alloyed quartz. The emission energy in the free-emission mode, with the prism stationary, and in the Q-switching mode with a repetition rate of 1 Hz was in both cases found to be approximately proportional to the pump energy. It was also found to depend on the time delay of shutter opening, a delay of approximately 0.4 ms being required for the emission energy to begin to increase appreciably and a delay of approximately 0.7 ms yielding the maximum emission energy during Q-switching with the prism. A giant emission pulse had a flat top, with a few humps most likely attributable to the low speed of the prism. Figures 3; references 3: Russian.

UDC 621.535.373

### Efficiency of Wide-Aperture Laser Amplifiers With Prismatic Active Elements

18620185c KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 5, May 88 (manuscript received  
1 Sep 87) pp 966-969

[Article by V. Ye. Novikov, G. V. Sklizkov, Yu. I. Terentyev, S. I. Fedotov, and A. A. Shcherbakov]

[Abstract] The energy characteristics of laser amplifiers with prismatic active elements are evaluated on the basis of theoretical design analysis and experimental performance data, wide-aperture amplifiers with prisms of Nd-glass and several pumping schemes with flash lamps being considered specifically. The gain was measured and its dependence on the pump energy thus determined with the aid of a continuous-wave YAG:Nd<sup>3+</sup>-laser through a collimator and a modulator, with the amplifier behind a high-reflectance mirror. The efficiency of excitation energy buildup and the density of inversion energy were also measured, for a determination of their dependence on the pump energy. The effect of thermo-optical distortions during pumping on the wavefront of the laser beam was measured with the He-Ne laser, its beam being collimated after passage through a glass with subsequent reflection first by the amplifier and then by the front face of that wedge. Change of the beam divergence from before to after a flash. The results confirm the practicality of using prismatic active elements for laser amplifiers. Figures 5; references 7: 6 Russian, 1 Western.

UDC 535.375

### Quasi-Soliton Mode in Dissipative Bistable System

18620185d KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 5, May 88 (manuscript received  
10 Apr 87) pp 975-977

[Article by A. V. Gayner and G. I. Surdutovich, Institute of Semiconductor Physics, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] The possibility of a soliton existing in a dissipative passive bistable system just as in a nondissipative one is demonstrated theoretically, a simple distributed system consisting of a ring cavity with a nonli-

near absorbing medium inside being considered as a specific example. A stationary quasi-rectangular pulse of duration shorter than the circulation period is assumed to travel around the cavity with appreciable dispersion, bistability of such a pulse being the necessary condition for its existence. Analysis and calculations are based on the stationary-oscillation theorem for the Schroedinger equation with an arbitrary amplitude and a phase nonlinearity of the bistability criterion, nonlinearity of the dispersion being described by the model of a sluggish two-level medium. Figures 2; references 7: 6 Russian, 1 Bulgarian.

UDC 621.373.8.029.71/73

**Behavior of Nb<sub>3</sub>Sn Superconducting Point Junction in Submillimetric-Wave Electromagnetic Radiation Field**

18620185e KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 5, May 88 (manuscript received 18 Sep 87) pp 1046-1048

[Article by E. M. Belenov, M. V. Danilenko, V. Ye. Derkach, V. I. Romanenko, and A. V. Uskov, Institute of Physics, UkSSR Academy of Sciences, Kiev]

[Abstract] An experimental study was made concerning the effect of submillimetric-wave laser radiation on an Nb<sub>3</sub>Sn superconducting point junction. In the experiment, the first one of this kind, such junctions were placed in a He-cryostat and exposed to 891 GHz (0.337 mm) radiation from a HCN-laser. The laser was excited electrically by direct current from a stabilized 5 mW source, this power being insufficient for triggering superconductivity in junctions with a high critical current. The equipment included a dielectric waveguide, electrical circuitry for junction control, and instruments for recording the current-voltage characteristics as well as intermediate-frequency beats. The measurements revealed that junctions with a critical voltage not lower than 1.5 mV and with a plateau in their current-voltage characteristics are effective frequency multipliers, the number of steps induced by laser radiation increasing with increasing width of the plateau. A correlation has been established between parameters of the junction and the ratio of its resistance above the plateau to its resistance along the plateau as well as its high-frequency characteristics. Beats at the intermediate frequency of 3.5 GHz were recorded, indicating a frequency conversion to approximately 2.7 THz. Figures 2; references 9: 3 Russian, 6 Western.

UDC 621.373.826

**Dependence of Power of Light Scattered by Aerosol Particles on Their Refractive Index**

18620185f KVANTOVAYA ELEKTRONIKA in Russian  
Vol 15 No 5, May 88 (manuscript received 25 Oct 87)  
pp 1050-1056

[Article by A. Drobnik and K. Pieszynski, Institute of Physics, Lodz Polytechnic Institute, Lodz, Poland]

[Abstract] A quantitative relation between the power of light scattered by aerosol particles and the refractive

index of the aerosol substance is established on the basis of Mie's theory, assuming spherical aerosol particles and a conical scattering pattern. Calculations and analysis reveal an oscillatory dependence of the scattered light power on the refractive index. There is a regular oscillation attributable to amplitude fluctuation of electric and magnetic partial waves, all of the same kind and order, the period of this oscillation being approximately equal to the ratio of radiation wavelength to particle diameter. There is also an irregular oscillation attributable to superposition of electric and magnetic partial waves of different orders from the first order up. Calculations are made in the approximation of a real rather than complex refractive index for 532.2 nm linearly polarized light waves from a He-Ne laser. The results can be useful for estimating the measurement error by an aerosol analyzer when the refractive index of the aerosol substance is unknown or when the aerosol contains particles of two different substances. Article was translated from English by B. F. Polkovnikov. Figures 7; references 8: 1 Russian, 7 Western (1 in Russian translation).

UDC 621.373.826:681.7.068

**Passage of High-Intensity Radiation From Lasers Through Quartz Fiber**

18620185g KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 5, May 88 (manuscript received 5 Apr 87) pp 1067-1074

[Article by V. G. Artyushenko, M. M. Bubnov, S. K. Vartapetov, Ye. M. Dianov, V. I. Konov, V. P. Pashinin, A. M. Prokhorov, and A. S. Silenok, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] The feasibility of using quartz fibers with reflective silicone coating for transmission of ultraviolet radiation from periodically pulsed excimer power lasers is examined on the basis of theoretical analysis and experimental data. For this purpose are evaluated the three basic fiber characteristics which determine the maximum transmittable pulse energy. First is determined the attenuation coefficient along a fiber at a constant input power and an constant ratio of output power to input power. Next is determined the efficiency of radiation entry into a fiber in terms of total internal reflection with minimum possible Fresnel-reflection loss. The radiation resistance of a fiber is determined on the basis of degradation measurements after 500-1000 pulses of gradually increasing energy, fiber breakdown occurring under different conditions at the entrance, along the uncoated initial lead-in segment, at the transition from uncoated to coated fiber, along the coated principal fiber segment, and at the exit. The results indicate that fibers of KUBI quartz 0.600 mm in diameter can transmit 351 nm radiation and 308 nm radiation as well as 248 nm radiation in pulses of up to 24 mJ energy from excimer lasers such as the experimental XeCl-laser for photoablation and angioplastic surgery. Figures 5; references 11: 5 Russian, 6 Western.



UDC 621.373.826.038.823

**Shaping Radiation Pattern of Excimer Laser by Means of Controllable Intracavity Mirror**  
18620038a Moscow KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 8(194), Aug 88 (manuscript  
received 6 Apr 88) pp 1525-1526

[Article by A. S. Akhmanov, M. A. Borontsov, A. V. Kudryashov, V. Ya. Panchenko, V. K. Popov, A. Yu. Poroykov, and V. I. Shmalgauzen, Moscow State University imeni M. V. Lomonosov]

[Abstract] In an experiment with an excimer (XeCl) laser its radiation pattern and thus beam structure were shaped by means of an electrically controllable mirror replacing a plain semiparabolic one in the cavity. The laser was an ELI-91 with a 1:10:1000 HCl:Xe:Ne active mixture operating under a pressure of 4 atm and emitting 308 nm radiation in pulses of 80 mJ energy and 30 ps duration without an expanding telescope. The cavity was formed by a plane-parallel quartz plate and an adaptively controllable semipassive bimorphous piezoelectric plate with reflective aluminum coating, maximum coverage of its surface by radiation from the discharge being ensured by an expanding telescope made of quartz with magnification. The first resonance frequency of the controllable mirror was 5 kHz. Figures 1; references 3: 2 Russian, 1 Western.

UDC 621.373.826.038.823

**Tunable XeCl-Laser Featuring High Spectral Luminance**  
18620038b Moscow KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 8(194), Aug 88 (manuscript  
received 20 Oct 87, after completion 18 Feb 88)  
pp 1545-1547

[Article by V. Ch. Belash, V. A. Kartazayev, S. Z. Lipinskiy, and V. L. Naumovich, Grodno State University]

[Abstract] A tunable XeCl-laser was built with the same 1.8:9:1800 HCl:Xe:He active mixture in both master oscillator and amplifier stages, which made it possible to produce a beam with only approximately 0.3 mrad divergence carrying radiation within an only approximately 1 pm wide spectral band in pulses of approximately 0.5 mJ energy and of 5-12 ns adjustable duration. The laser operated with a discharge voltage of 23 kV across a 60 pF storage capacitor with a 27 nF peaking capacitor. The cavity was formed by a plane dielectric mirror and a plane-parallel quartz plate. The tuner was formed by a dielectric high-reflectance (99.8 pct) mirror, a holographic grating (3600 lines/mm) mounted for grazing incidents, and a Littrow grating (3600 lines/mm). This laser featuring narrow-band high-energy emission was tunable over the 307.52-308.55 nm range, the width of the spectral line increasing as the angle of incidence of the holographic grating was increased. Figures 2; references 6: 2 Russian, 4 Western.

UDC 621.373.826

**Nonlinear Absorption and Emission of Microwave Radiation During by Ammonia Molecule Excited by Infrared Radiation**  
18620038c Moscow KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 8(194), Aug 88 (manuscript  
received 6 May 87) pp 1577-1586

[Article by G. N. Makarov, M. V. Sotnikov, and V. V. Tyakht, Institute of Spectroscopy, USSR Academy of Sciences, Troitsk (Moscow Oblast)]

[Abstract] An experimental and theoretical study of an  $\text{NH}_3$ -laser was made concerning excitation of its 0-to-1 transition, considering that multiphoton infrared excitation of its molecules is extremely inefficient owing to the large inversion split of the infrared levels of the  $\text{nu}_2$ -mode. In the first experiment a pulsed TEA  $\text{CO}_2$ -laser with frequency tuning by means of a diffraction grating served as the pump, use of a 4:1:16  $\text{CO}_2$ : $\text{N}_2$ :He active mixture with a low nitrogen content making it possible to produce "tailless" radiation spikes of 100 ns duration. Energy absorption was measured by the optothermal method with a pyroelectric detector as well as by the thermal method with calorimeters at both entrance to and exit from the laser cell. In the theoretical part excitation and absorption were analyzed by the simulation method on the basis of the conventional equations for noncoherent fast processes under a pressure not exceeding 1 mm Hg. In the second experiment emission of microwave radiation by  $\text{NH}_3$ -molecules was measured under conditions of total absorption of pumping infrared radiation, all far-infrared radiation being allowed to pass through the laser cell and its quartz or teflon exit window. The results indicate a possibility of more efficient excitation due to a field widening effect and a buildup of anomalous absorption due to removal of the rotational constraint by emitted microwave radiation. The authors thank Ye. A. Ryabov and I. Pak for helpful discussion of the results. Figures 5; references 23: 6 Russian, 17 Western (3 in Russian translation).

UDC 621.373.826

**Laser Converter With Modulated Pumping Radiation and Frequency-Compressed Noise**  
18620038d Moscow KVANTOVAYA ELEKTRONIKA  
in Russian Vol 15 No 8(194), Aug 88 (manuscript  
received 17 Sep 87) pp 1602-1606

[Article by A. V. Gusev and V. V. Kulagin, Moscow State University imeni M. V. Lomonosov]

[Abstract] A laser converter is proposed for gravitational receiver antennas, astrophysical research in which such antennas are used requiring a very high sensitivity. The



converter, a parametric nonregenerative one with two-component combination-frequency pumping, operates together with a degenerate parametric travelling-wave amplifier, a Weber photodetector, and a feedback channel. The measuring system for noise and sensitivity evaluation includes an optical modulator, namely a Fabry-Perot interferometer with a movable mirror and an external pump. Theoretical analysis in the single-mode approximation reveals the possibility of noise frequency compression for boosting the signal-to-noise ratio. Experimental studies concerning generation of an electromagnetic field which is frequency-compressed within the optical range are already underway. The authors thank V. B. Braginskiy and V. N. Rudenko for helpful discussions. Figures 1; references 17: 6 Russian, 11 Western (3 in Russian translation).

UDC 621.373.826:533.9

#### **Laser Plasma Formed From Target After Its Bombardment With Gamma Rays**

18620038e Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 8(194), Aug 88 (manuscript received 24 Apr 87) pp 1610-1614

[Article by M. R. Bedilov, Kh. B. Beysembayeva, S. A. Karamysheva, and M. S. Sabitov, Institute of Nuclear Physics, UzSSR Academy of Sciences, Tashkent]

[Abstract] An experimental study was made concerning interaction of laser radiation and a defective solid target, defectiveness of the target having been produced by its prior bombardment gamma rays. The target, a high-resistivity n-Si single crystal, was bombarded at about 70 deg C with gamma rays in doses up to 10 GR from a  $^{60}\text{Co}$  source having a power of 1.5 kR/s. It was then treated at room temperature under a vacuum of 1 mm Hg with radiation from a Nd-laser in 50 ns wide monopulses of 3 J energy, the beam with not more than 0.2 mrad divergence being focused by lens on a spot approximately 0.150 mm in diameter. The radiation power density on the target surface was varied over the 1-100 GW/cm<sup>2</sup> range by means of neutral light filters. Probing and testing of the ionic Si-plasma forming during this treatment, particularly measurement of its charge spectra,

indicate an appreciable effect of radiative defects in the target on its response to treatment with high-intensity laser radiation, optical breakdown of the target surface being more extensive and the resulting plasma being more highly charged when the target was a higher concentration of defects. Figures 2; references 13: 10 Russian, 3 Western (2 in Russian translation).

UDC 621.373.826.038.825.2

#### **High-Stability Subpicosecond Glass: Nd<sup>3+</sup>-Laser With Passive Mode Locking and Negative Feedback**

18620038f Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 8(194), Aug 88 (manuscript received 15 Oct 87) pp 1658-1659

[Article by K. Burneyka, R. Grigonis, A. Piskarshas, G. Sinkavichyus, and V. Sirutkaytis, Vilnius State University imeni V. Kapsukas]

[Abstract] An experimental study of glass:Nd<sup>3+</sup>-laser with passive mode locking an inertial negative feedback was made, its purpose being to generate light pulses of subpicosecond duration with high energy stability. The active medium of this laser was made of GLS23 phosphate glass doped with Nd, a 65 mm long rod 5 mm in diameter with an 87 deg bevel at both ends. The 1.2 m long cavity was formed by two dielectric mirrors, their reflectance being 99.8 percent and 50 percent respectively. Mode locking was effected by a methanol solution of 3274-u dye and negative feedback was provided by an electrooptic crystal, a Pockels cell, inside the cavity. A polarizer plate diverted some light to a plane mirror reflecting it to a photodetector, the latter converting it into an electric signal and sending that signal through an amplifier to the Pockels cell. Pulse trains of 0.3-0.8 mJ total energy and 500 ns total duration were generated, the negative feedback lengthening them to 0.002-0.050 ms depending on the initial transmittance of the dye and the duration of individual pulses of 0.001 mJ energy decreasing to 0.55 ps in about the middle of the train. The amplitude of feedback modulation was sufficiently large to ensure high stability of pulse energy and also of pulse duration, fluctuations of the latter not exceeding 10 percent and fluctuations of the envelope amplitude in the optimum configuration not exceeding 15 percent. Figures 2; references 7: ; 4 Russian, 3 Western.

UDC 539.142.3

**New Aspects of 'Interacting Bosons' Model**

18620157c Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA FIZICHESKAYA in Russian  
Vol 52 No 1, Jan 88 pp 111-118

[Article by Ye. G. Nadzhakov and I. N. Mikhaylov,  
Theoretical Physics Laboratory, Joint Institute of  
Nuclear Research]

[Abstract] The model of interacting bosons (A. Arima and F. Iachello) having already been expanded into the proton-neutron model of interacting bosons as well as into models of interacting bosons and fermions including dynamic supersymmetries for odd nuclei and for odd-odd nuclei, Ye. G. Nadzhakov and I. N. Mikhaylov describe a later model of many interacting bosons which they have recently developed and which they show generalizes the boson space without loss of some dynamic symmetries. The topical problem concerning the structure of nuclei is tackled from the standpoint of this new model with s-, p-, d-, f-bosons in compressed form (without d-bosons and without Coriolis interaction), with the minimum number of parameters necessary for calculating the Hamiltonian of the vibrational or any other limit. Calculations for nuclei with reflection asymmetry such as those of isotopes are included.  $^{218}_{88}\text{Ra}_{130}$ - $^{220}_{90}\text{Th}_{130}$ ,  $^{220}_{88}\text{Ra}_{132}$ - $^{222}_{80}\text{Th}_{132}$ ,  $^{228}_{88}\text{Ra}_{138}$ - $^{228}_{90}\text{Th}_{138}$ - $^{230}_{92}\text{U}_{138}$  are checked against experimental data already available on these isotopes. Figures 3; references 72: 2 Russian, 3 Bulgarian, 67 Western (2 in ELEMENTARY PARTICLES OF ATOMIC NUCLEUS).

**Soliton Mode of Turbulence**

18620018a Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 2, 25 Jul 88 (manuscript  
received 18 May 88) pp 79-82

[Article by V. Ye. Zakharov, A. N. Pushkarev, V. P. Shvets, and V. V. Yankov, Science Council on Comprehensive Problem of 'Cybernetics', USSR Academy of Sciences]

[Abstract] Strong wave turbulence describable by the quite universal nonlinear Schroedinger equation is analyzed for existence and behavior of solitons, a soliton not forming or an existent soliton becoming unstable under conditions of wave "collapse" in a turbulent process. Disregarding quantum effects, it is demonstrated on the basis of numerical simulation that in the general case of nonintegrability turbulence with a tendency toward uniform distribution of energy over degrees of freedom causes solitons to merge into fewer with larger amplitudes and in the special case of integrability solitons scatter one another elastically so that their number does not diminish. Calculations were made on computers of

the multiprocessor YeS-1037-2706 complex, using algorithms of fast Fourier transformation. Figures 2; references 9: 5 Russian, 4 Western.

**Masses of Neutrinos According to Data on Second Pulse of Neutrino Emission by SN-1987-A Supernova During Recorded Burst**

18620020a Moscow YADERNAYA FIZIKA in Russian  
Vol 48 No 2(8), Aug 88 (manuscript received 20 Aug 87)  
pp 483-486

[Article by M. I. Krivoruchenko, Institute of Theoretical and Experimental Physics, State-Controlled Institute of Atomic Energy]

[Abstract] According to data on the second pulse of neutrino emission by the XN-1987-A supernova during a recorded burst, 16 events having been recorded by the Kamiokande II detector and 8 events having been recorded by the IMB detector, there exist two diagonal neutrinos with Dirac masses of about 4 eV and 22 eV respectively. The possibility that the LSD could have at time 02:52:18 detected at least one event of a heavier antineutrino and a proton decaying upon collision into a positron and a neutron has been suggested by V. A. Lyubimov, of the five events actually detected by this LSD the one recorded at 02:52:02 and thus nearest in time having involved an energy of about 6.4 MeV. The author thanks O.G. Ryazhskaya and I. Totsuka for presenting additional data on LSD and Kamiokande II events, S.I. Blinnikov, I. Yu. Kobzarev, V. A. Lyubimov, and V. G. Uralov for helpful discussions and valuable comments, D.N. Voskresenskiy for discussion of problems related to cooling of neutron and pion-condensate stars, M. G. Shchepkin for discussion of constraints on neutrino mixing angles, and L.B. Okun for interest and elucidating comments. Tables 1; references 24: 9 Russian, 15 Western.

**Production of Muons With Improper Sign in Neutrino-Nucleon and Antineutrino-Nucleon Collisions**

18620020b Moscow YADERNAYA FIZIKA in Russian  
Vol 48 No 2(8), Aug 88 (manuscript received 3 Aug 87)  
pp 494-501

[Article by E. A. Choban, Leningrad Polytechnic Institute, and A. B. Onipchuk, Institute of Nuclear Research, USSR Academy of Sciences]

[Abstract] Production of muons with improper sign by the quasi-partonic mechanism in neutrino-nucleon and antineutrino-nucleon collisions is analyzed on the basis of weak interaction with a neutral current. The differential cross-sections for the respective two collision processes are calculated in accordance with the Breit-Wigner theory and in agreement with inclusive spectra of electron-positron annihilation, whereupon the distributions of these differential cross-sections over Bjerknes

variables  $x, y$  and the integral cross-sections are estimated with the aid of available experimental data. The authors thank A. A. Anselm for helpful discussion. Figures 6; references 13: 6 Russian, 7 Western.

### Weak Decays of Heavy Mesons and Mixing of Light Mesons

18620020c Moscow YADERNAYA FIZIKA in Russian Vol 48 No 2(8), Aug 88 (manuscript received 25 Nov 87) pp 512-514

[Article by G. L. Balayan and A. Yu. Khodzhamiryan, Yerevan Institute of Physics]

[Abstract] A new method of determining the quarkonium content in light isoscalar mesons is proposed, involving detection of these mesons in final states of weak decays of heavy (B and D) mesons. The procedure is demonstrated on a simplest transformation, namely semileptonic decay of a  $D_s$ -meson. Decay of a charm quark into a strange quark plus positron plus neutrino produces in the final state a pure strange quarkonium, which makes possible independent quantitative determination of strange and nonstrange quarks in the eta-prime meson. The authors thank Sh.S. Yeremyan and A.E. Nazaryan for helpful discussions. Figures 2; references 9: 1 Russian, 8 Western.

UDC 537.611

### Solitons in Quasi-One-Dimensional Magnetic Materials and Their Study by Method of Neutron Scattering

18620021 Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 155 No 4, Aug 88 pp 553-592

[Article by Yu. A. Izyumov, Institute of Metal Physics, Ural Science Center, USSR Academy of Sciences, Severdlovsk]

[Abstract] The theory of quasi-one-dimensional magnetic materials and particularly of their nonlinear dynamics is reviewed, beginning with the Kurmhan-Schrieffer model of a one-dimensional atom chain with two potential wells and considering that only in such magnetic materials does a soliton behave as a quasi-particle manifestable by its inelastic scattering of neutrons and in the thermodynamics of the system. A ferromagnetic material with a "plane of easy magnetization" anisotropy is considered in the first part of this review, its dynamics being reduced to a sine-Gordon equation for the phase. Three dynamic structural soliton factors are evaluated analytically, not only the longitudinal one and the transverse one but also the one representing the Fourier component of the magnetic or spin moment correlator in space-time domain. Interference of solitons and magnons is also accounted for. The second part deals with the theory of neutron scattering, for practical application of its method to study of soliton behavior in quasi-one-dimensional materials, the cross-section for this process being calculated first in general

terms with the directional factor taken into account. Experimental data pertaining to the  $\text{CsNiF}_3$  crystal (hexagonal with F-octahedra, separated by Cs-ions, surrounding Ni-ion chain) are analyzed and evaluated, measurements having been made with nonpolarized neutrons and with polarized ones. In the third part is considered a ferromagnetic material with finite anisotropy, fluctuations which knock spins out of the basis plane being monitored and existence of solitons being established in the thermodynamic behavior of such a material. In the fourth part are calculated quantum corrections, first in the quasi-classical approximation and then beyond its validity limits, taking into account discreteness of the spin chain and then considering solitons in a discrete ferromagnetic chain. In the fifth part is considered an antiferromagnetic material with a "plane of easy magnetization" anisotropy, its dynamics being also reduced to a sine-Gordon equation for the phase in the continuum approximation and found to differ from the dynamics of a ferromagnetic material with such an anisotropy. Both longitudinal and transverse dynamic structural soliton factors for such an antiferromagnetic material are evaluated, including their momentum-and-frequency dependence. The method of inelastic neutron scattering has been applied to study of spin dynamics in the  $(\text{CH}_3)_4\text{NMnCl}_3$  crystal (hexagonal with Cl-octahedra, separated by  $(\text{CH}_3)_4\text{N}$ -groups, surrounding Mn-ions chains), an antiferromagnetic material in which the anisotropy tends to retain spins in the basis plane, also in antiferromagnetic materials of the Ising kind such as  $\text{CsCoCl}_3$  and  $\text{CsCoBr}_3$  crystals in which the anisotropy tends to orient spins along the chain. The author thanks J. K. Kjems, K. Kakurai, M. Steiner, A. Luther, and H. S. Fogedby for the many discussions during his 1986 visit in Denmark. Figures 20; references 82: 12 Russian, 70 Western.

UDC 539.2

### Meaning of Concepts 'Phase' and 'Phase Transition'

18620037a Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 31 No 8, Aug 88 (manuscript received 19 Jan 87) pp 67-71

[Article by Yu. I. Paskal, Siberian Institute of Engineering Physics imeni V. D. Kuznetsov, Tomsk State University]

[Abstract] The concepts of phase and phase transition are analyzed for meanings beyond the general qualitative "state of a substance" and "change of state" respectively. Special definitions of "phase" have been formulated by Gibbs ("homogeneous part of a nonhomogeneous system on macroscopic scale") and by Ehrenfest ("state of a substance separated from other states by jump, discontinuity, or singularity of certain properties as functions of external intensive variables"). In the Landau theory of phase transitions there appears no definition of "phase,"

but symmetry is identified as its fundamental distinguishing feature. Phase and phase transition have been tackled mathematically, phase in geometrical terms of a  $\phi(p,T)$  surface and phase transition in terms of intersection of such surfaces or in terms of discontinuity or singularity of first, second, third derivative (depending on the kind of transition) of thermodynamic functions. A further contribution to these concepts was made by Hill in his thermodynamics of small systems. References 18: 10 Russian, 8 Western (5 in Russian translation).

UDC 548-162:539.16.04

**Buildup of Radiative Defects in Alkali-Halogenide Crystals During Combined Action of X-Rays and Pulsed High-Density Electron Beam**

18620037b Tomsk IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: FIZIKA in Russian  
Vol 31 No 8, Aug 88 (manuscript received 11 Sep 86)  
pp 100-102

[Article by Yu. M. Annenkov, T. S. Frangulyan, V. F. Stolyarenko, and A. M. Gornostayev, Tomsk Polytechnic Institute imeni S. M. Kirov]

[Abstract] An experimental study of KBr crystals was made concerning the buildup of radiative defects during simultaneous action of a continuous x-ray beam and a pulsed electron beam, KBr being a typical dielectric substance forming ionic crystals. The source of x-rays was a URS-55A tube with a Mo-anode operating at a current of 16 mA under a voltage of 50 kV. The source of 300 keV electrons with a current density of 61 A/cm<sup>2</sup> was an accelerator delivering them in pulses of 18 ns duration, their repetition rate being varied over the 0.666-0.016 Hz range. Electron beam and x-ray beam were made to enter a crystal from opposite directions, the thickness of a crystal being approximately 0.30 mm and thus slightly shorter than the mean free path of electrons. Defectiveness was monitored by recording the optical absorption spectra as well as by measuring the kinetics of F-centers and V<sub>2</sub>-centers, an electron beam known to effectively clusterize the hole-type products of radiolysis and x-rays known to stimulate their association. The results of the appropriately planned experiment confirm the theoretically predicted attenuation of radiative defectiveness caused by an electron beam. Figures 2; references 5: Russian.

UDC 539.186.22

**Resonant Photolysis of Negative Ion**

18620037c Tomsk IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: FIZIKA in Russian  
Vol 31 No 8, Aug 88 (manuscript received 24 Sep 86)  
pp 120-122

[Article by A. B. Voytkiv and V. A. Pazderskiy, Tashkent State University imeni V. I. Lenin]

[Abstract] Photolysis of a negative ion which has two discrete bound state by a strong electromagnetic field is analyzed theoretically, assuming that this is a one-electron

process and that the difference between the two corresponding energy levels is much smaller than twice the frequency of the field—with both electron mass and electron charge as well as the Planck constant all normalized and set equal to unity. Calculations are based on a system of two coupled equations equivalent to the Schroedinger equation and analogs of the Fadeyev-Hahn equations, the Psi-function of an electron being expressed as the algebraic sum of two parts. The electromagnetic field, its intensity divided by three-halves power of its frequency and its intensity divided by three halves power of the second ion energy level being much smaller than unity, is assumed to be linearly polarized but not capable of polarizing the atomic shell more than slightly. References 9: 1 Russian, 8 Western.

**Kinetics of Muon Catalysis Processes in Deuterium-Tritium Mixture Under Quasi-Steady Conditions**

18620148a Moscow ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 94 No 4, Apr 88 (manuscript  
received 8 Jan 87) pp 6-20

[Article by L. N. Somov, Joint Institute of Nuclear Research, L. I. Menshikov and M. P. Fayfman, Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] Muon catalysis in a D<sub>2</sub>-T<sub>2</sub> mixture is analyzed on the basis of equations describing the kinetics of fundamental processes which appear on the schematic diagram and which determine the spectra of  $\mu$  mesoatoms and  $d\mu$  mesomolecules, these spectra not differing more than by 10 pct and 5 pct respectively from the corresponding Maxwell distribution. Muon catalysis in the quasi-steady state, namely at a time much longer than the lifetime of a  $d\mu$  mesomolecule, is considered and the equations of kinetics are solved correspondingly in the quasi-stationary approximation. The rate of formation of  $d\mu$  mesomolecules at various temperatures up to and above 500 K is calculated with scattering of slow and fast  $\mu$  mesoatoms by nuclei in the D<sub>2</sub>-T<sub>2</sub> mixture as well as retardation of fast ones taken into account. A mathematical model describing the transient stage of muon catalysis and its quasi-steady state is then constructed in terms of numbers of slow and fast  $\mu$  mesoatoms which, upon colliding with molecules of the D<sub>2</sub>-T<sub>2</sub> mixture, form  $d\mu$  mesomolecules. References 36: 19 Russian, 17 Western.

**Dynamics of Electron Neutrino in Supernova and Constraints on Its Magnetic Moment**

18620165a Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 47 No 9, 10 May 88  
(manuscript received 28 Mar 88) pp 421-423

[Article by M. B. Voloshin, Institute of Theoretical and Experimental Physics, USSR Academy of Sciences]

[Abstract] The radial evolution of helicity of an electron neutrino in a medium such as a supernova with a magnetic field normal to the radius is evaluated on the basis of the

corresponding ballistic equation, for a determination of its magnetic moment, its amplitude being determined by coherent weak interaction of left-hand neutrino and electrons of the medium. Estimates including available data on the SN1987A supernova and particularly its density profile, the density of its core being of the order of  $10^{-12}$  g/cm<sup>3</sup>, indicate the possibility of resonant adiabatic complete reversal of the neutrino helicity within the supernova core when the magnetic moment of the electron neutrino is of the order of  $10^{-11}$  Bohr magneton. These estimates do not take into account fast energy transfer from center to periphery of the supernova core, which however at best affects only the first ejection of right-hand neutrino from the center within the first 10 ms. The author thanks S.I. Blinnikov for many helpful discussions. References 16: 6 Russian, 10 Western.

### New Kind of Resonances in Elastic Scattering

18620165b Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 47 No 9, 10 May 88  
(manuscript received 31 Mar 88) pp 424-427

[Article by D.I. Abramov, S.Yu. Ovchinnikov, and Ye.A. Solov'yev, Leningrad State University imeni A.A. Zhdanov]

[Abstract] The scattering matrix of two Coulomb centers  $Z_1 e Z_2$  ( $e$  equal to -1) is considered, exact numerical calculation of its poles having revealed narrow quasi-steady states identifiable as resonances of low orders. These resonances are not explainable on the basis of the Schrodinger equation for a one-dimensional quasi-radial problem in prolate spheroidal coordinates, even though this equation admits exact separation of variables, but evidently being associated with multi-dimensionality of the system and capture of a particle into a state of unstable equilibrium. An example is the hydrogen-like problem with virtual states transforming into quasi-steady ones by virtue of the energy dependence of the separation-of-variables constant. Trajectories of a particle leading to its capture are drawn in a nondimensional plane and trajectories of the S-matrix poles corresponding to various internuclear distances are plotted in the complex plane of the wave number. The authors thank S.S. Gershteyn and Yu.N. Demkov for helpful discussions, and V.V. Gusev for performing auxiliary calculations. Figures 2; references 9: 7 Russian, 2 Western.

UDC 621.315.592

### Deviation From Curie's Law in $Pb_{0.82}Sn_{0.18}Se:Mn$ Solid Solution

18620171a Leningrad FIZIKA TVERDOGO TELA  
in Russian Vol 30 No 4, Apr 88 (manuscript received  
25 Mar 87, in final version 16 Nov 87) pp 1221-1224

[Article by I. V. Misyura, Institute of Problems in Materialogy, UkSSR Academy of Sciences, Chernovitsy branch]

[Abstract] An experimental study of  $Pb_{0.82}Sn_{0.18}Se:Mn$  crystals was made, for a determination of their magnetic properties at low temperatures, magnetic ions in the lattice

known to be produced by exchange interaction of free charge carriers and electrons bound to impurity ions. Single crystals of  $Pb_{0.82}Sn_{0.18}Se$ , doped with  $2 \cdot 10^{16}$  cm<sup>-3</sup> Mn ions while being grown from the melt by directional crystallization, were sliced into wafers in the (100) plane. The wafers were isothermally annealed in vapor with excess Pb and Sn, for lowering the concentration of free charge carriers, whereupon they were polished with an etchant consisting of HBr and Br. Their magnetic susceptibility was measured by the relative Faraday methods with an electronic weighing balance over the 300-80 K temperature range, in a quartz container not constraining the degrees of freedom during volumetric changes. The diffraction peak 600 and its shifting were recorded in a DRON-2.0 x-ray diffractometer with a special goniometer. Electrical conductivity and Hall effect were measured by the compensation method. The results reveal an anomaly of magnetic susceptibility, deviation from Curie's law, owing to formation of magnetic domains at temperatures above 77 K with attendant formation of potential wells for conduction electrons near Mn ions. Peaking of the magnetic susceptibility is evidently caused by strong exchange interaction of bound charge carriers and the spin of magnetic ions. Figures 2; references 12: 6 Russian, 6 Western.

### Mixing of Toponium and $Z^0$ -Meson During Bhabha Polarization Scattering

18620162b Moscow YADERNAYA FIZIKA in Russian  
Vol 47 No 4, Apr 88 (manuscript received 23 Apr 87)  
pp 1064-1068

[Article by A. A. Pankov and I. S. Satsunkevich, Gorn' Polytechnic Institute]

[Abstract] Mixing of a V-meson (vector toponium) in the ground state  $J^{PS}$  equal to  $1^{--}$ , one of its resonance states, and a neutral gauge  $Z^0$ -meson during Bhabha "positron plus electron yielding positron plus electron" scattering upon collision of polarized particle beams is analyzed theoretically for its phenomenological consequences, considering both mass and energy dependence of measurable resonance and off-resonance polarization asymmetries. Measurement of both asymmetries makes it possible to experimentally determine the electroweak binding force of a neutral t-quark current for verification of calculated t-quark charge and isospin. This analysis and calculations also indicate the range of kinematic variables such as incidence angle and scattering angle within which interference effects, interference of Z-meson and V-meson states, of that mixing are most appreciable and thus most likely observable. In the case of nonpolarized incident particle beams, analysis and calculations indicate effects of a weak neutral t-quark current during inelastic annihilation of positron-electron pairs. Figures 8; references 9: 2 Russian, 6 Western.



**Two-Dimensional Vacuum Solitons in Weinberg-Salam Model in Magnetic Field**

18620174a Moscow YADERNAYA FIZIKA in Russian  
Vol 47 No 5, May 88 (manuscript received 7 May 87)  
pp 1336-1342

[Article by V. R. Khalilov, Moscow State University]

[Abstract] The effect of a strong magnetic field on the vacuum state of the Weinberg-Salam model with interaction of the field of electrically charged vector bosons and a Higgs field is analyzed, the appropriate system of equations describing the classical interaction being derived from the corresponding part of the Lagrangian containing the Minkowski tensor with (1,-1,-1,-1) signature. After necessary simplifying assumptions have been made, it is solved by the method of trial orbits yielding solutions in the form of solitons. In the quantum-mechanical model, the classical fields are averaged over the vacuum with respect to their operators so that the first of the two terms in the expression for the interaction potential can be regarded as representing the energy of "condensate of W-boson vapor." Also "instanton" solutions are examined, these solutions being localized ones with finite Euclidean actions and obtained by analytical continuation in the Minkowski space. References 11: 4 Russian, 7 Western (1 in Russian translation).

**Production of Heavy  $^1P_1$ -Quarkonia in Hadron-Hadron Collisions**

18620174b Moscow YADERNAYA FIZIKA in Russian  
Vol 47 No 5, May 88 (manuscript received 11 May 87)  
pp 1407-1413

[Article by R. A. Alanakyan, S. G. Grigoryan, L. S. Dulyan, and S. G. Matinyan, Yerevan Institute of Physics]

[Abstract] Production of heavy  $^1P_1$ -quarkonia with large transverse momentum in high-energy hadron-hadron collisions is analyzed and evaluated on the basis of the quantum-chromodynamic perturbation theory, in which the initial gluons are constituents of hadrons and the final gluon yields a hadron jet. The quarkonium model of a

nonrelativistic bound heavy quark-antiquark system is considered, its Bethe-Salpeter wave function being obtained by addition of spins with charge parity and colorlessness of the bound state taken into account. Calculations made for the three quarkonia ( $^1P_1$ -toponium,  $^1P_1$ -bottomium,  $^1P_1$ -charmonium) have yielded the dependence of the cross-sections for their production in stiff pp-collisions and pp-collisions with energy ranging from 63 GeV (ISR) and 540 GeV (CERN) to 2 TeV (Tevatron) and 6 TeV (UNK) on that energy, also of their second derivatives with respect to P on the transverse momentum of the respective quarkonium squared. The authors thank I. G. Aznauryan for interest and helpful discussions. Figures 8; references 30: 6 Russian, 24 Western.

**Quantization of Rotations of Axisymmetric Systems in Skyrme Model**

18620174c Moscow YADERNAYA FIZIKA in Russian  
Vol 47 No 5, May 88 (manuscript received 17 Apr 87)  
pp 1495-1503

[Article by V. B. Koneliovich, Institute of Nuclear Research, USSR Academy of Sciences]

[Abstract] The problem of quantizing the rotations of systems of interacting skyrmions is solved for such systems with axisymmetric configuration, the problem having already been solved for such systems with spherisymmetric configuration. It is solved by simultaneously quantizing orbital and spin or isospin rotations. The quasi-classical energy-momentum tensor and momentum as well as the moments of inertia are described in the Skyrme formalism, with the aid of Firtz relation for the Pauli matrix, first generally and then for the limiting case of two skyrmions topologically far apart. Quantization of rotations in the Skyrme model is then carried out, considering first an isotopic spin system and then classically stable exotic skyrmions with the transformation index an integer larger than 1. The author thanks B.Ye. Shtern for calculating the moments of inertia, S.V. Zenkin, L.A. Kodratyuk, Yu.A. Simonov, and I.S. Shapiro for helpful discussions. References 17: 4 Russian, 1 Polish, 12 Western.



UDC 535.33:537.534

**Determination of Oxygen in Surface Layers by Ion-Photon Spectroscopy**

18620022c Minsk ZHURNAL PRIKLADNOY  
SPEKTROSKOPII in Russian Vol 49 No 1, Jul 88  
(manuscript received 28 Apr 87) pp 81-85

[Article by S. A. Yevdokimov, V. V. Braslavets, and S. S. Pop]

[Abstract] An experimental study with ion-photon spectroscopy of metal layers was made, for the purpose of detecting by this method spectral emission lines of metal oxides and determining on this basis the oxygen distribution in such layers. Several transition metals (Ti, V, Cr, Fe, Ni, Zr, Nb, Mo, Hf, Ta, W) and several rare-earth metals (Gd, Tb, Ho, Tm, Yb) had been selected for this study, their oxides being dispersible into diatomic metal-oxygen molecules. Layers of these metals were bombarded with ion under vacuum and in an oxygen atmosphere under pressure sufficiently high for coating them with an oxygen submonolayer. Oxygen adsorbed and implanted during ion bombardment was found to disperse excited diatomic molecules luminescing within their characteristic spectral bands. The feasibility of layerwise quantitative analysis by this method for determination of the oxygen distribution in metal coating was established in an experiment with MOS-structures, specifically planar Mo-SiO<sub>2</sub>-Si structures. Figures 4; tables 1; references 11: 7 Russian, 4 Western.

UDC 537.76

**Resonant Raman Scattering of Light in Rhenium and Titanium**

18620171b Leningrad FIZIKA TVERDOGO TELA  
in Russian Vol 30 No 4, Apr 88 (manuscript received  
13 Mar 87, in final version 17 Sep 87) pp 986-989

[Article by Yu. S. Ponomov and G. A. Bolotin, Institute of Metal Physics, Ural Department, USSR Academy of Sciences, Sverdlovsk]

[Abstract] The spectra of first-order Raman light scattering in Re and Ti single crystals were measured, for a determination of their dependence on the excitation energy and on the temperature. They were measured in the (1010) plane of the Re single crystal and in the (0001) plane of the Ti single crystal, with a resolution of 4 cm<sup>-1</sup> and 1.5 cm<sup>-1</sup> respectively. Measurements at scattering resonance were calibrated against the rotational spectrum of nitrogen under identical conditions with laser excitation at various wavelengths as well as directly with a tungsten reference

source. The readings agree closely with those obtained by the method of inelastic neutron scattering and with amplification of light scattering by interference. The results indicate a peaking of the integral scattering efficiency in Re crystals at an exciting photon energy of approximately 2.5 eV and an attenuation of the E<sub>2g</sub>-phonon line. The frequency dependence of the integral scattering efficiency was measured, taking into account the transmission coefficient at the metal-vacuum boundary as well as the effective scattering length and the solid angle within which radiation scattered inside the crystal was measurable. Measurement of Raman scattering in the Ti crystal could be made only with the most powerful radiation at 488 nm and 515.5 nm wavelengths of an Ar-laser as excitation source. Figures 3; tables 1; references 14: 5 Russian, 9 Western (1 in Russian translation).

535.3:539.89

**Effect of High Pressure on Electronic Excitations in Luminescing Crystals**

18620160a Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA FIZICHESKAYA in Russian  
Vol 42 No 4, Apr 88 pp 802-808

[Article by A. I. Laysaar and G. S. Zavt, Institute of Physics, ESSR Academy of Sciences]

[Abstract] The effect of high and superhigh static pressure up to and above 100 kbars on interatomic distances and band-to-band transitions in inorganic compounds, specifically in crystals of alkali halides, is reviewed on the basis of theoretical and experimental studies including optical spectroscopy done at the Institute of Physics (ESSR Academy of Sciences) at 300 K, 77 K, 4.2 K temperatures. While high hydrostatic pressures are conventionally produced by a piston in a cylinder, superhigh pressures are now produced by compression between two diamond anvils. There are data available on exciton spectra of NaCl, KI, RbI, CsCl, CsBr, CsI crystals and on luminescence of self-localized excitons in these crystals. Data are also available on pressure-induced shifts of exciton transitions and of corresponding spectral lines along with isotropic effects in LiH and LiD crystals, these crystals having a band structure inverted relative to that of the alkali halides. The theoretically predicted conversion of all substances into metallic ones under a sufficiently high pressure merging all energy bands was confirmed experimentally by observable dielectric-to-metal transition of many crystals, such a transition of CsI occurring under a pressure of 1.7 Mbars rather than predicted 1.1 Mbars. The authors thank V.S. Shcherbakov and A.I. Kuznetsov for fruitful collaboration. Figures 3; references 37: 12 Russian, 25 Western.

UDC 533.951.2

**Theory of Production of Accelerated Electrons During Cyclotron Heating of Plasma**

18620025a Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 8, Aug 88 (manuscript received 10 Jun 87)  
pp 950-957

[Article by Ye. V. Suvorov and M. D. Tokman, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] Interaction of an electron and a microwave field in a plasma under conditions of electron-cyclotron resonance, with resulting acceleration of such an electron, is analyzed theoretically but taking into account real constraints. These are finiteness of the aperture of a microwave field along a magnetic line of force, possible nonuniformity of the magnetic field along the trajectory of the guiding center of motion, and nonadiabaticity of the flight of an electron across a microwave field causing it to gain some amount of energy in the process. The corresponding system of four equations describing electron ballistics in the nonrelativistic approximation is shortened by assuming approximately equal rates of change of the normalized magnetic moment and the normalized kinetic energy in dimensionless time. With the aid of phase portraits, this system of equations is analyzed for the dynamics of the corresponding Hamiltonian. In a uniform magnetic field the dimensionless amplitude of the resonance component of the microwave field and a nonrelativistic cyclotron frequency normalized to the microwave frequency, also the refractive index in the direction of the magnetic field, are constant. In a nonuniform magnetic field that dimensionless amplitude, as well as the phase difference between cyclotron rotation of an electron and electromagnetic radiation, is variable. The difference between a relativistic cyclotron frequency and a Doppler-shifted microwave frequency is accounted for in the equation of electron ballistics pertaining to the phase of cyclotron rotation. The authors thank A. S. Sergeyev for assistance in calculations. Figures 1; references 20: 10 Russian, 10 Western.

UDC 537.52

**High-Energy Electrons in High-Velocity Breakdown Waves**

1862025b Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 8, Aug 88 (manuscript received 17 Apr 87,  
after correction 10 Sep 87) pp 979-986

[Article by A. G. Abramov, E. I. Asinovskiy, and L. M. Vasilyak, Institute of High Temperatures, USSR Academy of Sciences]

[Abstract] An experiment was performed for a study of high-energy electrons in a waveguide with a liquid-dielectric retarding structure under conditions of breakdown by an electric field of intensity above critical, breakdown in long waveguides occurring in the form of high-velocity ionization waves. Pulses of up to 300 kV amplitude with negative polarity and of 35 ns duration

with 4 ns rise time were transmitted from their generator to an air-filled discharge tube through a matched coaxial line. One discharge tube, 200 cm long with a 5 mm inside diameter, matched a coaxial line filled with either water or transformer oil as insulator. Another discharge tube, 38 cm long with a 9.5 mm inside diameter matched only a coaxial line filled with water. Voltage and current measurements were made with the aid of capacitive voltage dividers, return current shunts, and Rogowski loops. The current of high-energy electrons was measured with a Faraday cylinder. Their x-ray emission during their slowdown in passage through eight successive 0.15 mm thick moderating glass plates was recorded with a FEU-87 high-speed photomultiplier and a scintillator. Measurements of the high-energy electron current and of the breakdown-wave current in the shorter tube have yielded the pressure dependence of their amplitudes and of the wavefront velocity in air. Measurements in the longer tube have yielded the pressure dependence of both the relative voltage amplitude and the attenuation coefficient characterizing electromagnetic oscillations over the pressure range most favorable for propagation of an electrical breakdown wave. Some analogy can be drawn with breakdown of a neutral gas by an electron beam. Figures 4; references 15: 11 Russian, 4 Western.

UDC 533.9.01

**Acceleration of Electrons During Stimulated Scattering of Electromagnetic Wave with Attendant Lowering of Its Frequency**

18620025c Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 8, Aug 88 (manuscript received 24 Sep 87,  
after correction 2 Dec 87) pp 1011-1014

[Article by N. I. Karbushev, Moscow Institute of Radio Engineering, USSR Academy of Sciences]

[Abstract] Stimulated scattering of electromagnetic waves by a relativistic electron beam with an attendant lowering of their frequency is considered, in connection with the development of free-electron lasers. While the frequency of scattered waves increases when they draw energy from the pump wave and from the electrons, their frequency decreases when their energy along with the pump energy is drawn by the electron beam so that electrons accelerate. Analysis of this process with a buildup of instability and limitation of the latter by some nonlinear saturation mechanism is based on its characteristic equation in the linear approximation, first assuming an infinitely long interaction space and taking into account its finite length, in which case acceleration of electrons is constrained by a threshold. Calculations for the specific example of a pump wave propagating collinearly with the electron beam and a scattered propagating in the opposite direction indicate that threshold conditions for acceleration of electrons following an increase of their kinetic energy by a large percentage are realistically attainable. The author thanks Ya. B. Faynberg for interest. References 7: 6 Russian, 1 Western.

533.9:621.039.627

**Comparative Characteristics of Soft X-Radiation in Apparatus of 'Plasma Focus With Mather's Geometry' Type**

18620182a Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 6, Jun 88 (manuscript received 19 Jun 87)  
pp 682-688

[Article by I. V. Volobuyev, V. A. Gribkov, N. V. Kalachev, T. A. Kozlova, O. N. Krokhin, and S. A. Startsev, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, S. Denus, S. Sledzinski, and S. Czekaj, Institute of Plasma Physics and Laser Microfusion imeni S. Kaliski, Warsaw [Poland]]

[Abstract] A comprehensive experimental study of soft x-radiation in plasma-focus apparatus, toward development of a compact and controllable high-power source of such radiation. Experiments were performed in the PF-150 facility with an either solid or hollow inner electrode (Institute of Plasma Physics and Laser Microfusion, Warsaw) and in the PF-30 facility with solid anode and titanium insert (Institute of Physics, Moscow). The instrumentation included several multiaperture camerae obscurae with RAR2490 photosensitive film for measuring the space distribution of electron temperature without time resolution and the absolute yield of soft x-radiation, one single-frame camera obscura with microchannel plate for measuring the space-time distribution of soft x-radiation with 10 ns time resolution, BPYP-30 photodiode detectors for measuring the time dependence of hard and soft x-radiation with 1 ns time resolution, and several spectrographs for recording the line spectrum of soft x-radiation and on this basis determining the temperature and the density as well as the charge content of the focus plasma. Not only current and voltage but also the rate of change of current and the absolute neutron yield were measured during each discharge, with the aid of photographs, the anisotropy of neutron emission being measured with active counters variously oriented relative to the axis of the apparatus. With pure deuterium and a solid anode, the absolute integral yield of soft x-radiation from the plasma focus was found to be of the order of 0.1 J in the PF-30 facility and of the order of J in the PF-150 facility with a hard component of x-radiation also present in each. The yield was 1.5-2 times higher with a hollow anode. The electron temperature was found to be 0.3-0.7 keV in both facilities, addition of argon raising the electron temperature in "hot spots" to 1.2-1.8 keV but not in "diffuse" regions. Addition of argon also increased the yield of soft x-radiation, by a factor of 5-7, the optimum Ar content being different for each facility. Shape and size of the plasma pinch were determined with the aid of an integral camera obscura, injection of hot anode plasma into the pinch region by means of a power laser being an effective way to increase the absolute yield of soft x-radiation by 2-3 orders of magnitude. The authors thank V. Ya. Nikulin for helpful discussions. Figures 10; references 13: 6 Russian, 7 Western.

533.951

**Adiabatic Effects in Dynamics of Langmuir Solitons**

18620182b Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 6, Jun 88 (manuscript received 29 Jun 87)  
pp 706-715

[Article by V. T. Astrelin and B. N. Breyzman, Institute of Nuclear Physics, Siberian Department, USSR Academy of Sciences, Z. Sedlacek and K. Jungwirth, Institute of Plasma Physics, Czechoslovak Academy of Sciences, Prague [Czechoslovakia]]

[Abstract] Nonlinear interaction of Langmuir waves and ion-acoustic waves is analyzed on the basis of the system of two one-dimensional Zakharov equations in the adiabatic approximation. Formation of long-lived compound solitons is shown to be possible under adiabatic conditions, as perturbations of the ion concentration vanish at infinity and the number of levels in the corresponding potential well is finite so that they are not too close to one another and to the edge of the continuous spectrum. Three kinds of elementary processes are considered, first interaction of a soliton and an ion-acoustic wave. Such an interaction cannot possibly result in breakup of the soliton, provided that the latter is either stationary or propagates at a sufficiently low subsonic speed. Interaction of solitons can result in their merging into an energetically more favorable one. Adiabaticity tends to limit the possibility of merging, especially for fast propagating solitons with a large population of plasmons, which in the process have to descend from a higher level to a lower one. Formation of solitons from free plasmons and particularly supersonic ones is possible when two plasmons are not too far apart, the soliton forming at a third location between them. Numerical analysis and estimates have yielded conditions favorable for this to occur, modulational instability being the principal source of new solitons when plasmon clusters are far apart and only one generation of solitons forming when the number of plasmon clusters is small. Figures 7; references 12: 9 Russian, 3 Western (1 in Russian translation).

533.9:535.211.3:621.375.826

**Experimental Study of Plasma Formation and Dispersal During Irradiation of Metals by Ultraviolet Laser**

18620182c Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 6, Jun 88 (manuscript received 19 May 87,  
after correction 23 Aug 87) pp 761-764

[Article by A. N. Panchenko and V. F. Tarasenko, Institute of High-Current Electronics, Siberian Department, USSR Academy of Sciences]

[Abstract] An experimental study of plasma formation and dispersal during irradiation of metal and other targets by an ultraviolet excimer laser was made, its purpose being to determine the dependence of the breakdown threshold, the plasma formation delay, and the plasma dispersal velocity on the target material as well as on the composition and the

pressure of the ambient atmosphere. As radiation source was used a LIDA-101 tunable XeCl\*-laser emitting pulses of up to 2 J energy at the 308 nm wavelength or pulses of up to 0.6 J energy at the 222 nm wavelength. The laser beam was focused by a quartz lens so as to form a spot 1.3 mm in diameter on the target surface. Metal targets (Al, Al-Be alloy, Ti, stainless steel, Cu, Ta, Pb) and dielectric targets (Si, Dacron, Teflon-4) were thus treated in various atmospheres (air, He, Xe) under pressures ranging from 760 torrs down to 4 torrs as well as under near vacuum with a residual air pressure of  $10^{-2}$  torr. The breakdown threshold was lowest, 25 MW/cm<sup>2</sup>, for the steel target. The shortest plasma formation delay, 3 ns, was attained on the Ta target in residual air. The fastest plasma dispersal, 11 km/s, was attained on the Al-Be target in air under a pressure of 4 torrs. Figures 2; tables 1; references 12: 8 Russian, 4 Western (1 in Russian translation).

UDC 533.951.8

**Magnetohydrodynamic Stability of Nonparaxial Open System With Annular Traps**

18620161a Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 3, Mar 88 (manuscript received 1 Mar 87,  
after correction 13 May 87) pp 301-305

[Article by V. V. Arsenin, Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] Magnetohydrodynamic flow of a plasma through axisymmetric traps, hollow superconducting cylinders, is analyzed for stability. First one such trap with an equatorial plane of symmetry is considered, the condition that the magnetic field in vacuo has a minimum on a line of force in this plane being that  $(d^2/dr^2 + d/dr)B^{-1}(r,0)$  be larger than zero. The magnetic field B is assumed to consist of a large uniform component and a small one alternating in space. Next a pair of coaxial traps is considered, a nonparaxial one contracting almost abruptly and an annular one inside the throat. Both the longitudinal pressure profile in such a system and the stability limit at the innerboundary are determined analytically, assuming a neutrally stable outer boundary. Figures 5; references 4: 2 Russian, 2 Western.

UDC 533.951

**Generation of Fast Electrons During Interaction of Microwave Radiation and Current-Carrying Plasma**

18620161b Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 3, Mar 88 (manuscript received 31 Jul 86,  
after correction 20 May 87) pp 312-319

[Article by V. Yu. Bychenkov, D. M. Karfidov, Ye. B. Kupriyanova, K. F. Sergeychev, and I. A. Sychev, Institute of Physics imeni P. N. Lebedev and Institute of General Physics, USSR Academy of Sciences]

[Abstract] An experimental study of ion-acoustic turbulence during action of high-intensity microwave radiation on a current-carrying plasma was made, for the purpose of determining its effect on the generation of fast electrons in the

process, ion-acoustic turbulence being induced by a current from an external source. The apparatus for this study included a cylindrical plasma chamber with a LaB<sub>6</sub>-coated thermionic cathode at each end and a tungsten anode-grid between them but closer to one, a horn-lens radiator emitting a microwave beam transversely across the plasma column to a flat microwave absorber on the other side, a Langmuir probe insertable into the plasma column, and a magnetizing coil behind each cathode coaxial with the plasma column. A longitudinally homogeneous argon plasma was generated by pulse discharge under a pressure of 50 mtorr in a longitudinal magnetic field not stronger than 100 G and ionized by a 2-3 keV electron beam with a current of 20 A. Its characteristics, namely radial profiles of electron temperature and concentration, were measured with the plasma quiescent and with the plasma carrying a current. In the latter case the radial profile of current density and fluctuation-noise as well as Kadomtsev-Petviashvili spectra between plasma-generating pulses were also measured. All these measurements were made first without a microwave radiation field and then with the plasma in a microwave radiation field. An evaluation of the experimental data has yielded a satisfactory agreement with estimates based on the theory of ion-acoustic turbulence. Figures 5; tables 1; references 16: 12 Russian, 4 Western.

UDC 535.24

**Envelope Solitons in Thin Layers of Magnetically Active Plasma**

18620161c Moscow FIZIKA PLAZMY in Russian  
Vol 14 No 3, Mar 88 (manuscript received 14 Mar 86,  
after correction 18 Dec 86) pp 353-356

[Article by L.M. Kerashvili, Institute of Cybernetics, GSSR Academy of Sciences]

[Abstract] Propagation of surface waves through an optically thin layer of cold dispersive plasma with a nonlinear permittivity tensor, in a strong transverse constant magnetic field, is analyzed on the basis of MHD theory and its vector field equations for both electron and ion plasma components. These equations are averaged and then integrated, with the first slow time derivatives retained and with variations of plasma density owing to surface waves taken into account. The results indicate that the envelope of such surface waves constitutes a soliton and propagates at its group velocity. The author thanks Yu. M. Aliyev for formulation of the problem and continuous attentiveness. References 5: 4 Russian, 1 Western.

UDC 533.951

**Weakly Nonlinear Theory of Interaction of Low-Density Electron Beam and Plasma**

18620172 Tbilisi SOOBSHCHENIYA AKADEMII  
NAUK GRUZINSKOY SSR in Russian  
Vol 129 No 2, Feb 88 (manuscript received 13 Jun 86)  
pp 289-292

[Article by N. I. Karbushev and G. G. Chigadze, Tbilisi State University]

[Abstract] Interaction of an electron beam and a plasma is considered, the object being to analytically describe the evolution of plasma-beam instability. This is done in the



weakly nonlinear approximation, including only second-harmonic perturbations ( $n=2$ ) and uniform perturbations with zero wave vector ( $n=0$ ) in addition to fundamental-frequency perturbations ( $n=1$ ). The system of equations for a monoenergetic electron beam passing through a boundless isotropic plasma with a higher equilibrium electron concentration is formulated assuming one-dimensional linear motion of electrons and a potential electric field of perturbations. Following a preliminary solution in the first (linear) approximation, it is solved in that second (weakly nonlinear) approximation adequate of fairly accurately calculating the first maximum amplitude of plasma oscillations and the time at which it occurs. The amplitude obtained by this analytical method is 23 pct lower than that based on numerical solution. References 5: all Russian.

UDC 534.19

#### **Anisotropic Characteristics and Spatial Correlation of Oceanic Noise Field**

18620110a Moscow *AKUSTICHESKIY ZHURNAL*  
in Russian Vol 34 No 1, Jan 88 (manuscript received  
24 Nov 86) pp 8-11

[Article by A. A. Aredov, Institute of Acoustics imeni N. N. Andreyev, USSR Academy of Sciences]

[Abstract] The space-time correlation functions of the oceanic noise field are determined from its anisotropic characteristics on the basis of a noise generation model, in a geometrical acoustics approximation, for a layerwise homogeneous ocean with noncorrelated acoustic dipoles uniformly spaced over its surface. Two nondirectional receivers a distance  $d$  apart are considered in a steady horizontally isotropic and vertically anisotropic noise field of intensity  $I(a, f)$  ( $a$  - angle from vertical,  $f$  - frequency). Using the normalized space correlation function for zero time delay and a finite frequency band with center frequency  $f_0$ , calculations of the sound velocity profile have been made for the tropical zone with underwater channel, for the temperature zones in winter, for the circumpolar zone with surface channel, and for a shallow-wave region. Vertical noise radiation patterns have been calculated for a receiver at a large depth of 200 m as well as for receivers at small depths of 100 m and 50 m. The results show that while the noise field at a receiver in the tropical zone and in the circumpolar zones is formed by local sources with an energy dip about the horizontal directions and by remote sources with an energy peak about the horizontal directions respectively, in the temperature zones it is appreciably influenced by the ocean bed. The results pertaining to deep-water regions have been generally confirmed by experimental data based on measurements. Figures 2; references 8: 5 Russian, 3 Western.

UDC 551.463

#### **Low-Frequency Dynamic Noise in Randomly Nonhomogeneous Ocean**

18620110b Moscow *AKUSTICHESKIY ZHURNAL*  
in Russian Vol 34 No 1, Jan 88 (manuscript received  
24 Jun 87) pp 12-18

[Article by V. V. Armelnny, I. N. Didenkulov, and M. A. Rayevskiy, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] Available experimental data on the dynamics of low-frequency noise in oceanic waveguides, underwater acoustic channels, are theoretically interpreted by including multiple scattering of acoustic waves by large-scale inhomogeneities in a randomly nonhomogeneous ocean rather than on the basis of the simpler but inadequate model of a regular lossy plane-laminar oceanic acoustic waveguide. A refractive waveguide is considered within which statistically uniform and horizontally isotropic three-dimensional fluctuations of the acoustic velocity occur. Analysis of the noise dynamics is based on the equation for intensity of normal waveguide modes in the "forward scattering" approximation and assuming a Garrett-Munk spectrum of internal waves. The calculated space distribution of noise intensity and frequency characteristic of noise gain agree closely with experimental data based on measurements at low wind velocity, application of the Wentzel-Kramers-Brillouin method being helpful in the case of high wind velocity with dominant effect of local noise sources and negligible dissipation. Figures 3; references 15: 10 Russian, 5 Western.

UDC 534.222

#### **Use of Sound Ray Representation for Calculating Acoustic Field in Oceanic Waveguide by Method of Quasi-Normal Waves**

18620110c Moscow *AKUSTICHESKIY ZHURNAL*  
in Russian Vol 34 No 1, Jan 88 (manuscript received  
7 May 87) pp 44-48

[Article by N. A. Veshev, Leningrad Institute of Aviation Instruments Design]

[Abstract] The acoustic field in an oceanic waveguide is calculated by use of the sound ray representation in a system of dimensionless two horizontal and one vertical coordinates. Analysis of the problem is based on the model of a weakly irregular waveguide rather than a plane-laminar one and on the method of quasi-normal waves, their phase velocity being calculated in the adiabatic approximation and ignoring the continuous part of the spectrum. Not all normal modes contribute to the acoustic field in such waveguides but only those with eigenvalues of the transverse operator in the direction of propagation close to singular points on the eikonal. Eigenfunctions of the transverse operator in the vertical plane in the direction of propagation are expanded into Wentzel-Kramers-Brillouin asymptotic series, whereupon summation of modes is performed according to the Poisson formula with cosines replaced by their exponential equivalents according to the Euler formula. The eikonal is then obtained in terms of Airy functions in the Fock notation and the phase velocity of quasi-normal waves is calculated by solution of the wave equation. Numerical results are shown typical of

a point sound source and quasi-normal waves whose source lies between reversal points of the wave equation. The author thanks S. Yu. Slavyan for discussion. Figures 3; tables 1; references 4: all Russian.

UDC 551.463.21

**Effect of Absorbent Seabed on Frequency Spectrum of Noise Field in Shallow Water**  
*18620110d Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 34 No 1, Jan 88 (manuscript received 14 Nov 86) pp 172-174*

[Article by Ye. I. Derevyagina and B. G. Katsnelson, Voronezh State University imeni Lenin Komsomol]

[Abstract] The spectral intensity density of a noise field produced in shallow water by distributed surface sources is calculated, assuming that the noise sources are statistically

independent dipoles. The noise field at frequency  $f$  produced by an individual dipole with moment  $M$  is proportional to the sum of functions representing normal modes, each multiplied by the value of its first derivative at the source, these modes being obtainable from the solution to the corresponding Sturm problem and expressed here in the Wentzel-Kramers-Brillouin approximation. An analysis of the results reveals that the contribution of nearby noise sources, which produce the continuous part of the spectrum, is negligible for a receiver located above a not too strongly absorbing seabed but not too close to the surface. The effect of the seabed is significant, especially when its boundary is rough so that scattering of acoustic waves occurs. This is confirmed by data on the frequency spectrum of a noise field which indicate much stronger noise attenuation, throughout the 30-1000 Hz frequency range, by a sand bed (rough) than by a clay bed (smooth). Figures 1; references 8: 4 Russian, 4 Western (2 in Russian translation).



**High-Temperature Superconductivity of  
Tl-Ba-Ca-Cu-O Ceramic**

18620018e Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 48 No 2, 25 Jul 88 (manuscript  
received 9 Jun 88) pp 103-105

[Article by B. B. Boyko, A. I. Akimov, V. I. Gatal'skaya, S. Ye. Dem'yanov, A. L. Karpey, I. A. Kurochkin, Yu. N. Leonovich, A. K. Letko, M. N. Muraya, M. L. Petrovskiy, A. N. Plevako, L. P. Poluchankina, T. V. Polyakova, Z. A. Romanenko, Ye. K. Stribuk, and I. M. Starchenko, Institute of Solid-State and Conductor Physics, BSSR Academy of Sciences]

[Abstract] The authors produced a high-temperature superconductor thallium ceramic  $Tl_{1.4}BaCaCu_{1.5}O_y$  from a stoichiometric mixture of  $Tl_2O_3$ ,  $BaCO_3$ ,  $CaCO_3$ ,  $CuO$  powders by sintering it after compaction at 810-870 deg C for 1-10 h, one batch of compacts being then ground to powder for a second such compaction and sintering cycle. Structural examination and phase analysis in an x-ray diffractometer with a  $CuK_{\alpha}$  radiation source yielded respectively the lattice parameters and the spectrum of a pseudotetragonal phase. Magnetic measurements by the induction method in a field of 30 kOe intensity revealed a volume superconductivity with a weak but perceptible Meissner effect. While in the twice sintered ceramic the Meissner effect started already at 126 K and leveled already at 119.5 K, in the once sintered ceramic it started only at 125.5 K but a second superconducting phase appeared at 112 K. These conclusions are supported by the results of electrical resistivity measurements. Figures 3; references 6: 1 Russian, 5 Western.

**Fine Structure in Nuclear-Magnetic-Resonance  
Spectra of Cu in  $YBa_2Cu_3O_{6.0+x}$**

18620165c Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 47 No 9, 10 May 88  
(manuscript received 25 Apr 88, after revision  
23 Mar 88) pp 451-453

[Article by V. V. Serikov, A. M. Bogdanovich, S. V. Verkhkovskiy, Yu. I. Zhdanov, B. A. Aleksashin, and K. N. Mikhalev, Institute of Metal Physics, V. L. Kozhevnikov and S. M. Cheshnitskiy, Institute of Chemistry, Ural Department, USSR Academy of Sciences]

[Abstract] An experimental study of  $YBa_2Cu_3O_{6.0+x}$  with x ranging from 0.00 to 0.95 was made, for the purpose of explaining the preferential filling of the 04 position in  $Cu1-0$  chains with increasing oxygen content on the basis of nuclear-quadrupole resonance on  $Cu2$ . Specimens were produced from the  $YBa_2Cu_3O_{6.95}$  phase by reducing heat treatment under controlled oxygen pressure. After isothermal soaking at 800 deg C under the equilibrium oxygen pressure corresponding to each given oxygen content, they were cooled at a rate of 1 deg/min in accordance with the p-T-x diagram so as to

maintain the given oxygen content in the process and to ensure their monophasic constitution. This was ascertained by neutron diffraction and x-ray structural analyses. Spectra of nuclear-quadrupole resonance on  $Cu2$  were recorded by the spin-echo method in an ISSh-2-13 spectrometer at 78 K temperature over the 18-35 MHz frequency range, with square pulses of 0.003 ms duration separated by 0.040-0.050 ms intervals sufficiently long for echo pickup. Analysis of these spectra has revealed a fine structure, with a redistribution of line intensity upon change of the oxygen content evidently attributable to attendant change in the components of the electric-field-gradient tensor. The authors thank V.I. Voronin for divulging the results of neutron diffraction analysis prior to their publication. Figures 3; references 6: 1 Russian, 5 Western.

**Superconductivity of Electron Flow Near  
Crystallization**

18620165d Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 47 No 9, 10 May 88  
(manuscript received 28 Mar 88) pp 454-456

[Article by V. S. Babichenko and A. N. Kozlov, Institute of Atomic Energy imeni I.V. Kurchatov]

[Abstract] Transition of an electron flow, as its concentration decreases, from homogeneous to nonhomogeneous ground state at a critical concentration with attendant appearance of either a charge density wave or a spin density wave prior to formation of a Wigner crystal is shown to be always (in every model) result in an effective attraction between electrons possibly leading to superconductivity. Wide concentration fluctuations indicate that the static two-particle vertex with momentum transfer from particle to hole has a singularity of the resonance kind, this vertex not depending on the spin as long as both homogeneous and nonhomogeneous phases are paramagnetic. The necessary condition for stability of the system is shown to be a negative coefficient A in the resonant part of the static vertex on the RPA diagram. References 7: 5 Russian, 2 Western.

**Rise of Critical Current for Metal-Oxide Ceramic  
Under Pressure**

18620165e Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 47 No 9, 10 May 88  
(manuscript received 28 Mar 88) pp 457-459

[Article by V. G. Baryakhtar, O. V. Grigut, A. V. Vasilenko, A. I. Dyachenko, V. M. Svistunov, V. Yu. Tarenkov, and O. I. Chernyak, Donetsk Institute of Engineering Physics, UkSSR Academy of Sciences]

[Abstract] An experimental study of  $YBa_2Cu_3O_{7-d}$  ceramic was made, for the purpose of determining the pressure dependence of its critical current. Thin specimens in the form of 0.08 mm thick wafers 0.5 mm wide and 6 mm long, with a density of 5.95 g/cm<sup>3</sup>, were

produced by compaction of powder and subsequent annealing at 900 deg C. These specimens consisted of closely packed flat single crystals with a thickness of the order of 0.020 mm, their electrical resistivity varying over a wide range. Two pairs of copper contact tabs, one for current and one for voltage, were deposited on each specimen by vacuum deposition. The hydrostatic pressure in the test chamber was varied up to 10 kbars and measurements were made with alternating current up to 0.050 mA, currents up to 0.100 mA having been found to affect neither width nor form of the superconducting transition range of the resistance-temperature characteristic. The results indicate a sharp rise of the critical current with rising pressure, the critical current becoming approximately twice as high upon a pressure rise from 1.5 kbars to 8.5 kbars, with an attendant 5-10 pct decrease of electrical resistance. Figures 2; references 4: 2 Russian, 2 Western.

#### **Superconducting Phases $UBe_{13}$ and $U_{1-x}Th_xBe_{13}$**

18620165f Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 47 No 9, 10 May 88  
(manuscript received 28 Mar 88) pp 460-463

[Article by I. A. Lukyanchuk and V. P. Mineyev, Institute of Theoretical Physics imeni L. D. Landau, USSR Academy of Sciences]

[Abstract] The superconducting transition of  $UBe_{13}$  and  $U_{1-x}Th_xBe_{13}$  is discussed, the superconducting transition temperature having been found to depend nonmonotonically on the amount of Th replacing U. Analysis of available experimental data covering the 0-6 pct range of Th content indicates that the lowest superconducting transition temperature corresponds to 1.75 pct Th under normal pressure and shifts to increasingly higher Th content with rising pressure, no transition occurring with 3 pct Th under 10 kbars but again occurring with higher than 3 pct Th content. Formation of a new phase mixing with rather than replacing the existent one when the Th content exceeds 1.75 pct is the most plausible interpretation consistent with phase transitions of the second kind, occurring here below the superconducting transition temperature. Four possible schemes of such transitions are considered. Transition from normal metal through superconductor with  $O(T) \propto R$  symmetry to superconductor with  $D_3(C_3) \propto R$  symmetry with attendant strong ultrasound absorption when the Th content is higher than approximately 1.75 pct and transition from normal metal to superconductor with  $D_3(C_3) \propto R$  symmetry directly when the Th content is lower than approximately 1.75 pct are the two schemes consistent with experimental evidence. V.P. Mineyev thanks P.Kumar for preliminary discussion. References 19: 7 Russian, 12 Western.

#### **Magnetic Properties of $YBa_2Cu_3O_x$ Single Crystals in Weak Magnetic Fields**

18620165g Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 47 No 9, 10 May 88  
(manuscript received 22 May 88) pp 474-477

[Article by I. I. Makarenko and S. M. Stishov, Institute of Crystallography imeni A. V. Shubnikov, USSR Academy of Sciences, L. Z. Avdeyev, A. V. Volkozub, O. V. Snigirev, and V. V. Khanin, Department of Physics, Moscow State University imeni M. V. Lomonosov]

[Abstract] An experimental study of  $YBa_2Cu_3O_x$  single crystals was made, for a determination of their magnetic properties in weak transverse and longitudinal magnetic fields of up to 1000 Oe intensity at temperatures above superconducting transition. Two sets of specimens from the same growth batch were used, stacks consisting of identically oriented crystals and weighing 1.5-2 mg, one batch of rhombic twin crystals annealed in an oxygen stream (superconducting transition temperature 92-93 K, transverse electrical resistivity 0.250 mohm.cm at 300 K) and one batch of tetragonal crystals neither chemically nor heat treated (superconducting transition temperature 50-60 K, transverse electrical resistivity 0.010 mohm.c, at 300 K). Their magnetic moment and magnetization were measured, those of the first batch over the 90-120 K temperature range and those of the second batch over the 30-80 K temperature range, for a determination of the magnetic volume susceptibility. Noteworthy is that the susceptibility of the unannealed and therefore defective specimens as well as that of annealed ones was found not to be anisotropic and not to depend on the temperature, within experimental accuracy, above the superconducting transition. Figures 3; references 9: all Western.

#### **New High-Temperature Superconductor**

**$BiCaSr_{0.7}Al_{0.5}Cu_4O_y$**   
18620165h Moscow PISMA V ZHURNAL  
EKSPERIMENTALNOY I TEORETICHESKOY  
FIZIKI in Russian Vol 47 No 9, 10 May 88  
(manuscript received 6 Apr 88) pp 478-479

[Article by K. S. Aleksandrov, A. D. Vasilev, S. A. Zvegintsev, M. I. Petrov, and B. P. Khrustalev, Institute of Physics imeni L. V. Kirenskiy, Siberian Department, USSR Academy of Sciences]

[Abstract] A new high-temperature superconductor material not containing a rare-earth element, namely  $BiCaSr_{0.7}Al_{0.5}Cu_4O_y$ , has been synthesized by standard ceramic technology from a mixture of respective oxides and carbonates. The color of the specimens is black and their ground surface has a metallic luster. The ingredients of the mixture were monitored by the x-ray method in a DRON-2 diffractometer with a  $CuK_{\alpha}$  radiation source and a monochromator, the debyegram of a fine-crystalline specimen revealing only CuO. The temperature dependence of electrical resistivity, measured by the

current-voltage method, indicates coexistence of two phases. The superconducting transition of the regular phase extends over the 75-60 K temperature range, the upper limit being weakly current-dependent. The superconducting transition of the anomalous phase occurs at 104 K. Measurement of the magnetic moment in a weak field of 3 Oe intensity has confirmed the existence of two phases, diamagnetic behavior being evident not only below 75 K but already within the 104-75 K range. Figures 3; references 1: Western.

UDC 621.315.592

**Energy Distribution of Electrons or Excitons in System of Nonequilibrium Phonons**

18620171c Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 4, Apr 88 (manuscript received 8 Dec 87) pp 1161-1166

[Article by Ye. L. Ivchenko and L. b. Takunov, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] The dependence of the energy distribution of particles, electrons or excitons, with an isotropic parabolic spectrum on the frequency distribution of acoustic nonequilibrium phonons interacting with these particles is established theoretically on the basis of the corresponding equation of kinetics and its solution in the quasi-elastic approximation. An exact numerical solution is obtained for excitons in a  $\text{Cu}_2\text{O}$  crystal containing excitons, with not only exciton-phonon interaction but also finiteness of the exciton lifetime taken into account. Including interaction with transverse acoustic phonons is found not to appreciably alter the energy distribution of excitons based on their interaction with longitudinal one only and finiteness of the exciton lifetime raises the effective exciton temperature in the case of an equilibrium phonon distribution, while there are two temperatures with transition from one to the other at some critical energy level in the case of a nonequilibrium phonon distribution. Experimental data on the exciton distribution in a hot spot fit these theoretical relations and the corner frequency of the phonon distribution can be established on this basis. The authors thank A.V. Akimov, A.A. Kaplyanskiy, and Ye.S. Moskalenko for formulation of the problem and helpful discussions. Figures 3; references 7: 5 Russian, 2 Western.

UDC 538.945

**Electron-Paramagnetic-Resonance Spectra and Magnetic Properties of  $\text{RBa}_2\text{Cu}_3\text{O}_7$  (R- Y, Sm, Eu, Ho) High-Temperature Superconductors**

18620171d Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 4, Apr 88 (manuscript received 10 Nov 87) pp 1210-1214

[Article by N. B. Brandt, V. V. Moshchalkov, A. A. Gippius, A. N. Tikhonov, I. E. Graboy, A. R. Kaul, and Yu. D. Tretyakov, Moscow State University imeni M. V. Lomonosov, Moscow]

[Abstract] An experimental study of four high-temperature superconductor materials ( $\text{YBa}_2\text{Cu}_3\text{O}_7$ ,  $\text{SmBa}_2\text{Cu}_3\text{O}_7$ ,

$\text{EuBa}_2\text{Cu}_3\text{O}_7$ ,  $\text{HoBa}_2\text{Cu}_3\text{O}_7$ ) with superconducting transition within the 97-91 K temperature range and with 80-90 pct magnetic shielding at 4.2 K temperature was made, for a measurement of their EPR spectra and a determination of their magnetic properties. Polycrystalline specimens were produced by the cryochemical method from salts of the ceramic-forming components, namely by fast freezing of their aqueous solution and sublimation of the ice followed by thermal dilatation of deiced ceramic at 800 deg C and sintering at 950 deg C in an oxygen atmosphere. This technology produced pure 123-phase specimens, as confirmed by x-ray phase analysis. The concentration of paramagnetic centers was found to vary from 0.0015 in  $\text{YBa}_2\text{Cu}_3\text{O}_7$  to 0.0232 in  $\text{EuBa}_2\text{Cu}_3\text{O}_7$ , measurements having been made with "Varian" EPR spectrometers E-4 and E-104 at the 10 GHz frequency on specimens crushed to powder of the 0.010 mm grain size so as to eliminate the skin effect at that frequency. These measurements were made at both 293 K and 787 K temperatures. The results indicate a very small contribution of Cu ions to the EPR signal in  $\text{YBa}_2\text{Cu}_3\text{O}_7$  typically, even though 60-70 pct of all Cu ions should be bivalent when the average valence is 2.3 in an electrically neutral configuration. This insignificant participation of  $\text{Cu}^{2+}$  ions, not more than 0.15 pct of all Cu ions, in electron-paramagnetic resonance could possibly be attributed to electron-spin-resonance according to the Anderson model of resonating valence bonds. The authors thank V.F. Anufrenko for interesting and helpful discussion. Figures 3; tables 1; references 5; 1 Russian, 4 Western (1 in Russian translation).

UDC 539.2

**Role of Phonon Mechanism in Superconductivity of Lanthanum Ceramics**

18620171e Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 4, Apr 88 (manuscript received 2 Dec 87) pp 1240-1242

[Article by A. N. Kozlov, L. A. Maksimov, and V. V. Pushkarev, Institute of Atomic Energy imeni I. V. Kurchatov, Moscow]

[Abstract] The strong interaction of conduction electrons and low-frequency optical phonons of oxygen atoms in  $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$  compounds is analyzed, the experimentally detected soft mode in the phonon spectrum of these compounds evidently corresponding to a structural transition with neighboring oxygen octahedra tilting toward one another. The "soft phonon" superconducting transition temperature is estimated theoretically, assuming that conduction electrons belong to the Cu-O chain where they form a quasi-two-dimensional structure consisting of two layers per lattice and that each oxygen octahedron oscillates rotationally about the Cu atom at its center. Calculations are based on the electron-phonon Hamiltonian and the Eliashberg equation. The sought temperature is found to be highest at zero dispersionless frequency of the soft mode, depending not only on the dielectric permittivity at that frequency but also on the electron-ion interaction potential and on the relative

electron mass  $m/m_0$  ( $m_0$ -zero frequency electron mass) as well as on the relative layer width  $d/h$  ( $h$ - distance from the vertex of an oxygen octahedron to the conducting plane). Numerical integration of two expressions, for the dielectric permittivity based on quasi-two-dimensional shielding in the approximation of random phases and for the electron-ion interaction potential determined by the two-dimensional momentum  $p-p'$ , yields the upper bound for that temperature as a function of all these parameters. The authors thank Yu. Kagan and v.A. Somenkov for helpful discussions. Figures 1; references 5: 1 Russian, 4 Western.

UDC 539.2

**'High-Temperature' Quantum Size Effect in Semimetals**

*18620102a Leningrad FIZIKA TVERDOGO TELA in Russian Vol 30 No 1, Jan 88 (manuscript received 17 Jun 87) pp 23-27*

[Article by V. M. Polyanovskiy, Zaporozhye Institute of Machine Design imeni V. Ya. Chubar]

[Abstract] Quantum size oscillations anomalously slowly decaying with rising temperature and therefore called "high-temperature" ones are analyzed, such oscillations along with

those of kinetic coefficients having been detected in films of semimetals (Bi,Sb) and being stimulated by singularities of the density of states near levels of dimensional quantization in thin films when the film thickness changes. Isenergetic band-to-band electron and hole transitions from one level of dimensional quantization to another is proposed as the mechanism of this anomaly. The theory of this mechanism is based on an isotropic model with a nonmonotonic dependence of the oscillation period on the film plane orientation relative to the crystallographic axes. Calculations including a harmonic analysis pertaining to films sufficiently thick for many quantization levels do adequately interpret experimental data on the electrical conductivity of thin Sb films. References 8: 7 Russian, 1 Western (in Russian translation).

**Stochastic Game With Complete Information but No  
Equilibrium Situation in Pure Stationary Strategies**

18620173b Moscow *USPEKHI MATHEMATICHESKIKH  
NAUK in Russian Vol 43 No 2(260), Mar-Apr 88*  
(manuscript received 7 Apr 86) pp 135-136

[Article by V. A. Gurvich, Institute of Terrestrial Physics  
imeni O.Yu. Shmidt, USSR Academy of Sciences]

[Abstract] A stochastic two-player nonzero-sum game is  
devised in which each player has complete information-  
but no Nash equilibrium situation exists in pure sta-  
tionary strategies. Following the definition of five basic

concepts relevant to such a game and of various kinds  
of games falling into this class, an example of a cyclic  
game is shown which constitutes an ergodic broaden-  
ing of a 3x3-bimatrix game. It is shown to be minimal  
game, inasmuch as an ergodic broadening of a 3xk-  
bimatrix game has at least one equilibrium situation,  
while a cyclic zero-sum game has a saddle point.  
References 2: 1 Russian, 1 Western.



UDC 517.43+519.11

**Convex Shells or Orbits in Representations of Finite Groups and Combinatorial Optimization**

18620024a Moscow FUNKTSIONALNYY ANALIZ in Russian Vol 22 No 3, Jul-Sep 88 (manuscript received 17 Dec 87) pp 66-67

[Article by A. I. Barvinok and A. M. Vershik, Leningrad State University imeni A. A. Zhdanov]

[Abstract] The combinatorial structure of convex shells in representations of symmetric finite groups is considered and such a shell of the orbit of a general point is shown to be, with a few exceptions, an exponentially compound polyhedron. A theorem stating that the number of highest-dimensionality polyhedron faces  $P_{pi}(\lambda_{\text{mbda}})$  increases not less than by  $2^n$  for a  $k$  larger than 1 is proved with the aid of a lemma pertaining to a conical shell of several orbits. A theorem stating that two combinatorial problems of  $\pi$ -designations, namely mass problem 1 and validity problem 2, are respectively NP-difficult and NP-complete for a  $k$  larger than 1 is proved with the aid of two lemmas. An approximate solution of problem 1 is shown to be possible with an algorithm based on a theorem pertaining to  $n$ -cage diagrams and Young diagram. References 5: 2 Russian, 3 Western (2 in Russian translation).

UDC 515.510

**New Aspects of General Topology Associated With Forcing**

18620106a Moscow USPEKHI MATEMATICHESKIKH NAUK in Russian Vol 43 No 4(262), Jul-Aug 88 (manuscript received 28 Jul 87) pp 83-94

[Article by V. I. Malykhin, Moscow Institute of Control and Management imeni S. Ordzhonikidze]

[Abstract] Consequences of forcing in general topology are examined, following its description in the language of partly ordered sets without consideration of Boolean forcing but with reference to axiomatic systems and Goedel's theorem. New set-theoretical systems, namely Zermelo-Frenkel continuum plus axiom or continuum hypothesis, are analyzed for absolute or relative results. Such results are not necessarily obtainable except with forcing, the result then being a metamathematical one. Three formulations of metamathematics in general topology are outlined: 1) if  $A$  is compatible with the Zermelo-Frenkel continuum, then  $B$  is also compatible with it, 2) for  $P$  to hold true,  $Q$  must hold true, 3) on a premise  $S$ , object  $K$  can exist. New topics further studied include: A. Extension of the known range of existence of topological and set-theoretical objects, B. Topological manifestations of incompleteness of the Zermelo-Frenkel continuum (typical problems: 1. is there a perfectly normal bicomact in the Zermelo-Frenkel continuum with a density indeterminate

in it?, 2. are there two spaces  $X_1$  and  $X_2$  in the Zermelo-Frenkel continuum such that  $c(X_1)$  equal to  $c(X_2)$  equal to  $\aleph_0$  but with the Suslin number of product  $c(X_1 \times X_2)$  indeterminate in this continuum?), C. Construction of topological and set-theoretical objects conservable during generic expansions. References 23: 6 Russian, 1 Czechoslovak, 16 Western (2 in Russian translation).

UDC 517.951

**Topological Analysis of Hydrodynamic Flow Structures**

18620106b Moscow USPEKHI MATEMATICHESKIKH NAUK in Russian Vol 43 No 4(262), Jul-Aug 88 (manuscript received 7 Jul 86) pp 129-158

[Article by O. V. Troshkin, Computer Center, USSR Academy of Sciences]

[Abstract] Steady two-dimensional flow of an ideal and thus nonviscous incompressible fluid within a bounded region is analyzed from the topological standpoint, with reference to Euler's equations of hydrodynamics. Extension of Morse structures is followed by consideration of potential flow. A Vortex is then superposed on a simple flow and then a reversing flow, with the Vekua-Berse boundary-value problem for potential flow appropriately modified with spectral constraint for homogeneous boundary conditions. An analytic solution and then a smooth analytic solution to this, considering flow within a rectangular region with possibility of "vortical catastrophe," are validated by a uniqueness theorem. The author thanks A. A. Dezin for reading the manuscript with many valuable comments and V. I. Arnold for referring to a vast literature on the subject of three-dimensional flow. Figures 18; references 72: 34 Russian, 38 Eastern (6 in Russian translation).

UDC 517.5+517.44

**Integration of Vector Stratifications**

18620026 Moscow FUNKTSIONALNYY ANALIZ I EGO PRILOZHENIYA in Russian Vol 22 No 2, Apr-Jun 88 (manuscript received 14 Oct 86) pp 14-25

[Article by F. F. Voronov and A. V. Zorich, Moscow State University imeni M. V. Lomonosov]

[Abstract] Integration on vector stratifications is explored and compared with integration on a smooth supermanifold, considering that the apparatus of superanalysis facilitates description of not only Fourier and Radon integral transformations but also many classical problems in integral geometry. A review of fundamental concepts and notations, including tangential and normal stratifications of a supermanifold, is followed by analysis of integral transformations and dual integral transformations from forms and from pseudoforms on normal or conormal stratification to forms on the Grassmanian manifold as

well as of the Baranov-Shvarts transformation and Fourier transformation from pseudodifferential forms to forms on conormal stratification. Each of these transformations is validated by an applicable theorem. All these objects of integration are interrelated, the basic diagram depicting transformations with permutable differential and integral

being a commutative one. The authors thank S.P. Novik for interest and support, A.S. Shvarts for describing how he and M.A. Baranov used the classical Fourier transformation for calculating the cohomology of pseudo-differential forms in the  $R^{m/n}$  Abelian supergroup. Figures 3; references 8: Russian.

UDC 517.94

**Differential Equation With Small Parameter at Highest-Order Derivative**

18620019a Kiev UKRAINSKIY MATEMATICHESKIY ZHURNAL in Russian Vol 40 No 4, Jul-Aug 88 (manuscript received 4 Jan 87, after completion 2 Apr 87) pp 417-424

[Article by G. S. Zhukova, Voronezh University]

[Abstract] A nonhomogeneous linear one-dimensional ordinary differential equation of  $n$ -th order with a small parameter  $s$  not only at the highest-order derivative  $s^n c(t,s)(d^n x/dt^n)$  but also in the exponential free terms  $s^q f(t,s)e^{s r_{A(t)}}$  on the right-hand side is considered which admits an asymptotic representation as this small positive parameter tends to zero, the solution to the second-order equation having already been thoroughly analyzed. Analysis of solutions to this equation of generally any higher than first order, covering any numerical relation between  $p, q, r$  and assuming that a condition of resonance exists, is facilitated by transformation of the equation through an appropriate change of variable  $x(t,s)$  and subsequent application of the Zhukova-Chernykh method of diagrams. The correctness and the effectiveness of constructing a formal solution to this nonhomogeneous equation by this method, which has been originally developed for the corresponding homogeneous one, is validated by six theorems with the aid of one lemma. References 11: 8 Russian, 3 Western.

UDC 517.9

**'Shortening' Denumerable System of Differential Equations With Impulse Terms**

18620019b Kiev UKRAINSKIY MATEMATICHESKIY ZHURNAL in Russian Vol 40 No 4, Jul-Aug 88 (manuscript received 10 Dec 87) pp 481-487

[Article by S. P. Pogovchenko, Institute of Mathematics, UkrSSR Academy of Sciences, Kiev]

[Abstract] The denumerable system of ordinary differential equations of the hyperbolic kind with impulse terms  $dx_k/dt$  equal to  $eX_k(t, x_1, x_2, \dots)$  and  $\Delta x_k/t_i$  equal to  $eI_{ik}(x_1, x_2, \dots)$ , obtained as a result of "averaging," is "shortened" in the K.P. Persidskiy sense by equating all  $x$  and functions of  $x$  with index  $k$  larger than some  $n$  to zero so that all equations after the  $n$ -th can be omitted. All remaining functions  $X_k$  and  $I_{ik}$  ( $i=1, 2, \dots$ ) are assumed to be continuous in their variables and to satisfy the Cauchy-Lipschitz condition. For a validation of this procedure, a Banach space of piecewise-continuous functions which have discontinuities of the first kind and make a sequence uniformly convergent on some interval  $[0, T]$  is introduced and two existence theorems are proved for a solution to the "shortened" system of equations. References 6: Russian.

UDC 517.98

**Functional Superanalysis**

18620173c Moscow USPEKHI MATEMATICHESKIKH NAUK in Russian Vol 43 No 2(260), Mar-Apr 88 (manuscript received 19 Nov 87) pp 87-114

[Article by A.Yu. Khrennikov, Moscow Institute of Electronic Engineering]

[Abstract] Functional superanalysis, which combines analysis on infinite-dimensional spaces and analysis with anticommutative variables, is overviewed with inclusion of pseudodifferential operators. First is considered analysis on a superspace over a commutative Banach superalgebra. Next is considered analysis on a superspace over commutative supermodules. Definition of Feynman distribution and Feynman measure, for a quantum system with boson and fermion coordinates in a Hilbert space of states, is followed by a review of pseudodifferential operators for superanalysis. The general theory of superspace is outlined, covering algebraic and topological objects, differential calculus and analytic functions, also superspace over an arbitrary algebra. In the overview are 13 propositions and 26 theorems are stated and 11 supporting definitions and 145 illustrative examples are given, some referring to Lie  $G$  superalgebras and to infinite-dimensional or finite-dimensional Grassman algebras. Possible extensions of functional superanalysis and problems yet to be solved include integral Fourier operators on supermanifolds, selection of superalgebra, diffusion process in superspace, fundamental solutions to differential operator equations other than those with the Laplace operator, Laplace operator on superspace, and differential forms on infinite-dimensional supermanifolds.

**Fundamental Solutions to Differential Equations of Certain Class in Anisotropic Spaces of Generalized Functions**

18620145 Moscow USPEKHI MATEMATICHESKIKH NAUK in Russian Vol 43 No 1(259), Jan-Feb 88 (manuscript received 24 Apr 86) pp 215-216

[Article by A.P. Chernyayev, Moscow Institute of Engineering Physics]

[Abstract] In space  $DS(R_{m,n}^{m \text{ plus } n})$  of fundamental functions the convergence criteria for a sequence of continuously differentiable functions and for a sequence of continuously differentiable functions and for a sequence of generalized functions are defined, any linear continuous functional being a generalized function. The equation  $L(y, D_x, D_y)F=0$  is then considered,  $L(y, D_x, D_y)$  being a finite sum and  $F(s, y)$  being the solution with  $x$  in set  $R^m$  and  $y$  in set  $Y$ . An existence theorem is stated and

proved for the solution  $F(x,y)$  to this equation in the case where  $L(y,D_x,D_y)$  appears in the form  $\Delta_x$  plus  $D_y^2$  plus  $P'(y)/P(y) D_y^1$ , with  $P(y)$  given for any  $y$  in set

$R^1$  and the solution  $F(x,y)$  being an integral over set  $R^m$ . The author thanks Professor V.B. Lidskiy for his assistance in this study. References 5: 4 Russian, 1 Western.

UDC 519.248

**Theoretical and Statistical Research on Defect Set in Enamel Varnish Electrical Insulations**

18620077e Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 303 No 2, Nov 88 (manuscript received 6 Apr 87) pp 270-274

[Article by R. P. Braginskiy, B. V. Gnedenko, academician, Ukrainian Academy of Sciences, G. M. Zaytseva and S. A. Molchanov, Moscow State University imeni M. V. Lomonosov]

[Abstract] The theory of extremal values is applicable and effective in research on the properties of electrical insulation of wires and cables. This is illustrated in Gaussian and Poisson breakdown models. However, the findings for polyethylene and polyvinyl chloride insulations differ from those for enamel varnish insulations. The latter are extremely sensitive to a number of factors. These are described and taken into account in the further analysis of breakdown probability. This was investigated using six different types of enamel varnish insulations. Breakdown tests without aging were made for one consignment, making it possible to evaluate the role of "inherent defects." Four other consignments were subjected to high-temperature aging in a thermostat, followed by breakdown tests. The results for all six types of wires were qualitatively close. Within the framework of the homogeneous theory a model is described which explains all the observed qualitative phenomena and affords the possibility for a quantitative analysis of both the structure of the "inherent defect set" and the aging process. The technology of fabrication of enamel varnish insulations is discussed in order to explain the origin of the defects responsible for aging and breakdown. The findings will be applicable to research on other types of insulation. Figures 2; references 4: 3 Russian, 1 Western.

UDC 519.676:519.24

**Uniform Optimization of Monte-Carlo Method Weighting Evaluations**

18620077b Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 303 No 2, Nov 88 (manuscript received 15 Dec 87) pp 290-293

[Article by G. A. Mikhaylov, corresponding member, USSR Academy of Sciences, and A. A. Shiglyavskiy, Computation Center, Siberian Department, USSR Academy of Sciences; Leningrad State University imeni A. A. Zhdanov]

[Abstract] Many Monte-Carlo method algorithms are based on choice of some distribution probability  $P$  stipulated in the measurable space  $(x, B)$  and having the density  $p = dP/dv$ , modeling of the  $P$  distribution and using the resulting sample, an evaluation of a finite or infinite set of linear functionals. The effectiveness of these algorithms is dependent on the choice of the probability density function  $p$  and is determined by some functional stipulated in

a set of admissible densities  $p$  and being a composite of integral functionals linearly dependent on  $1/p$ . There are many variants of such algorithms, such as weighting algorithms in the Monte-Carlo method, dependent on the parameter; weighting algorithms in the Monte-Carlo method in a case when the nucleus of the integral operator is dependent on the parameter, algorithms of the Monte-Carlo method for simultaneous evaluation of several integrals. The article gives procedures for uniform optimization of such weighting evaluations and these represent a refinement and broadening of the materials given in a monograph by the senior author entitled "Optimizatsiya Vesovykh Metodov Monte-Karlo," Moscow, Nauka, 1987, and in a monograph by the junior author entitled "Matematicheskaya Teoriya Optimalnogo Eksperimenta," Moscow, Nauka, 1987. References: 6 Russian.

**Some New Quasi-Universal Classes of Groups**

18620016 Tbilisi SOOBShCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian Vol 130 No 2, May 88 (manuscript received 23 Jan 86) pp 245-248

[Article by Sh. S. Kemkhadze, Batum Pedagogical Institute]

[Abstract] New classes of groups axiomatizable by quasi-universal formulas in the Maltsev sense and satisfying the local theorem are identified, on the premise that the class of groups  $\Sigma$  is such one. Two theorems aided by three lemmas, each followed by a corollary, state that the two classes of groups  $q_0\Sigma$  and  $s_0\Sigma$ , subclasses of groups  $I^n_0\Sigma$  with any natural number  $n$  the two classes groups  $k_0\Sigma$  and  $q_0s_0\Sigma$ , also the generalized Schmidt class  $l_0\Sigma$  and the generalized Schmidt classes  $I^n_0\Sigma$  with any natural number  $n$  are quasi-universal and thus local. An earlier third theorem states that subclasses of groups  $I^n_0\Sigma$  and  $I^n_0q_0\Sigma$  with any natural number  $n$  are local, if the class of groups  $\Sigma$  is local but not necessarily quasi-universal. Article was presented by Academician R. V. Gamkerlidze on 18 December 1986. References 11: 10 Russian, 1 Western.

**Determinism of Random Levi Fields and Unitary Representations of Infinite-Dimensional Groups**

18620173a Moscow USPEKHI MATHEMATICHESKIKH NAUK in Russian Vol 43 No 2(260), Mar-Apr 88 (manuscript received 15 Dec 86) pp 151-152

[Article by G. I. Olshanskiy, Institute of Geography, USSR Academy of Sciences]

[Abstract] A random Levi field is defined on a metric space and its determinism, namely the property that the trajectories of random processes generated by some field averaging are analytic functions, is explained in a broader sense with the aid of two theorems and a corollary to one. The proof is based on unitary representations and holomorphism of certain groups. References 6: 2 Russian, 4 Western (1 in Russian translation).



UDC 534.23:519.6

**Solution of Wave Equations by Implicit Difference Method**

18620107d Moscow *AKUSTICHESKIY ZHURNAL*  
in Russian Vol 35 No 1, Jan-Feb 89 (manuscript  
received 15 Mar 88) pp 37-42

[Article by A. V. Gladkiy, Cybernetics Institute, Ukrainian Academy of Sciences]

[Abstract] Much attention is now being devoted to the development of effective approximate methods for computing acoustic fields described by elliptical or parabolic equations. Various modifications of the parabolic equations method, usually with use of implicit difference schemes, are in wide use for investigating fields at great distances from a source. Their realization requires solution

of systems of linear algebraic equations with complex coefficients. A study was made of implicit three-layer difference schemes for solving boundary value problems for elliptical and wave equations in inhomogeneous regions. Conditions were found under which these schemes are stable. The results of numerical experiments are given and a comparative description of the considered difference problems is presented. As an example, a difference scheme is proposed for approximating solution of the corresponding boundary value problem for the Helmholtz equation; its solution is represented in the form of the sum of normal modes. Since a propagation angle can be related to each mode, a comparison was made of difference schemes as a function of the number of modes taken into account, that is, as a function of the maximal propagation angle. The results are presented in the form of graphs. Figures 2; references 7: 5 Russian, 2 Western.

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